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Thomas Hunt
Carpenter and Joiner's Assistant;

CONTAINING

PRACTICAL RULES

FOR

MAKING ALL KINDS OF JOINTS, AND VARIOUS METHODS
OF HINGEING THEM TOGETHER;

FOR HANGING OF DOORS ON STRAIGHT OR CIRCULAR PLANS;

FOR FITTING UP WINDOWS AND SHUTTERS TO ANSWER VARIOUS PURPOSES,
WITH RULES FOR HANGING THEM:

For the Construction of *Floors, Partitions, Soffits, Groins, Arches for Masonry*;
for constructing *Roofs* in the best Manner from a given Quantity of Timber:

For placing of *Bond Timbers*; with various Methods for adjusting *Raking Pediments*, enlarging and diminishing of Mouldings; *taking Dimensions* for Joinery, and for setting out *Shop Fronts*.

With a new Scheme for constructing *Stairs* and *Hand-rails*, and for Stairs having a Conical Well-hole, &c. &c.

TO WHICH ARE ADDED,

EXAMPLES OF VARIOUS ROOFS EXECUTED,

WITH THE SCANTLINGS, FROM ACTUAL MEASUREMENTS.

With RULES for MORTICES and TENONS, and for fixing IRON STRAPS, &c.

Also Extracts from *M. Belidor, M. du Hamel, M. de Buffon*, &c.

On the STRENGTH OF TIMBER, with Practical Observations.

Illustrated with SEVENTY-NINE PLATES, and copious Explanations.

By PETER NICHOLSON,

AUTHOR OF THE CARPENTER'S NEW GUIDE, &c.

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X

P R E F A C E.

IN my former publication, *The Carpenter's New Guide*, I have laid down and treated on many useful parts of the Carpenter and Joiner's professions; yet upon examination and reflection, there appeared various branches of which no notice had been taken by any author; and as some of these are of considerable importance and of frequent application, they appeared not unworthy of my attention and consideration; and the more so, as it is necessary those cases should be best understood, which most frequently arise in business: of these examples, which occur every day, is the major part of this book composed; and which must be considered as a Supplement to, or Second Part of, the Carpenter's Guide, although in some instances the same subjects are again treated of in this book; of these I must say the examples are totally different, and the principles on which they are explained new, and in some cases better—and will I flatter myself tend to the ease of the workman and the perfection of the work.

Of Soffits an entire new example is shown for covering an oblique cone, which may be applied where the surface is any part of an oblique cone; the next example is for covering a soffit which is level at the crown and fluing upon the sides; and I must observe this method is preferable to my former one; yet neither of these problems will be absolutely true in practice, as a plane surface can never apply with absolute accuracy to such a winding surface; but either rule will answer the workman's purpose.

On the subjects of Groins or Cross-arches, are given some lines, the principles of which are entirely new and preferable for practice to any before published. I have taken this opportunity of introducing some new inventions applicable to Arches for Masonry: on this subject we have no instructions in the English language.

Of the best constructions of naked Floors, and of the proper disposal of Bond-timbers in walls, some examples are given, with explanations of the various parts; these cannot fail of being peculiarly useful to the young builder: of similar use also will be the example for framing Partitions. Among the various new examples in that very important part of building, the Roof, I have introduced a different scheme to that in the Carpenter's Guide, for forming one, the plan of which is a trapezium; by the construction here laid down, the eye will not be offended by the roof's winding, for all the sides, according to this construction, are planes; and therefore, if the top be parallel to the horizon, it will be either a triangle or a trapezium, and the roof will not wind at all. To this article is properly added some useful examples for Sky-lights, and one entirely new is given of a conical figure, cutting through the inclined side of a roof; of which it may be observed, that the curb on the inclined side of the roof is the perspective representation of the circle *A, B, C, D, &c.* Plate 21, or base of the cone, when the eye is at the vertex, *K*.

On the subject of Niches, I am enabled to offer some new and useful rules, of which I beg leave here to observe, that on Plate 22 is very simple in its construction, and may readily be put in practice; the method of fixing the ribs differs from that described in the Carpenter's Guide; but the principles of getting the curve of the ribs is the same; yet I must observe, the former method is the strongest and best, if the niche is to be lathed and plastered: the present example is better adapted for a niche intened to be boarded. The design on Plate 23, is not so proper for Carpentry, as all the ribs require backing, and each requires a particular centre, as having a different curve. This and the following example therefore are given as hints to the workman, showing the various methods of constructing niches, applicable or proper for plasterers work, and may be attended with advantages when circumstances require a varied construction. On Plate 25, is shown the manner of constructing a circular niche in a circular wall; the manner of getting the curve of the ribs is the same as described in the Carpenter's Guide, but the manner of fixing them is better adapted to practice, requiring fewer lines and less time to execute.

To the young or inexperienced workman, the next plate will be of peculiar service, though explaining so familiar a subject as framing of Angles, which are applicable to Dados, Skirtings, Backs and Elbows, Troughs, Water-spouts, &c.

An

P R E F A C E.

v

An useful manner of taking Dimensions without taking the angles is shown in the example of a soffit on pannelling of any kind, for which a piece of framing may be wanted.

In those instances which I have, and not improperly, called every-day examples, I hope my present labours will be particularly serviceable to workmen in general, by the explanations of the true principles of Hinges, and by the numerous examples applicable to every situation. The methods of making Joints for the purpose of being Hinged together, and also the methods of hingeing them, is shown in the most ample manner, and forms a very valuable article to every Joiner, wishing to excel in his profession; and I think it scarcely possible but in the most difficult situations something will be found applicable; and it is possible they may all come into use, in going through an extensive business.

The next article is not of inferior importance, and the principles here laid down will lead to sure methods for Hanging of Doors in general, and for finding the meeting joints of folding doors; for in general, doors are not hung to the best advantage; and few workmen know any certain method by which to adjust properly the meeting-joint of folding-doors. When folding-doors are hung upon a straight plan, it is true they require but little bevel, and are therefore generally done by guess; but if they are hung upon a circular plan, to open inwards, then a rule is absolutely necessary, they will else be in danger of being made too narrow.

In the whole range of the Joiner's business there is no part which requires more skill and accuracy than in what belongs to Windows, I mean Sashes, their Frames and Shutters, and which have never yet been explained: it has been my endeavour to give instructions proper for setting out windows and shutters for various purposes, and to show a true method for cutting shutters necessary for any opening. I must here observe, these plates will be of singular use to persons in setting out work for Building, as well as to workmen.

A general method for enlarging or diminishing of Mouldings is shown; also the methods for finding the Mitres of raking Mouldings for straight or for circular pediments. That for straight pediments is not very different from the one in the Carpenter's Guide, but is shown rather more clearly here; but the method for mitering a circular pediment, and particularly for the mouldings, has never before been shown: connected with this is the method for setting out cornices for Shop fronts.

On

On that important and intricate part of the business Stair-cases, to which I have given particular application and attention, I have now the satisfaction to make public, several great improvements and new articles. On Plate 60, is shewn a method different from that in the Carpenter's Guide, for glueing up a rail in thickness, and which is plainer and more easily understood. Then follows a method accurate and true, for executing a Stair-case and Hand-rail, either out of the solid, or in thickness, when the well-hole is in the form of a frustrum of a cone; a solution or true method for which has never been shown in any work. Finally, there is a method for cutting the but-joints and for placing the falling mould to the solid piece after its being plumbed, a rule very much wanted in practice, and which will render the application of the moulds absolutely certain.

Having thus enumerated the heads of contents of this part of the book, and pointed out their usefulness in practice, it remains only for me to say, that as in my former work I have united Theory and Practice, in this I have joined to the practical part some ideas of Embellishments, giving to the doors and windows the fashionable mouldings, pannels and jambs.

It may be proper for me here again to observe, that this book will not supersede or render useless my former publication *The Carpenter's New Guide*, by no means; the subjects, a few instances only excepted, are totally different: the two volumes will form a complete treatise on the Carpenter and Joiner's business: besides, the Elements or Principles, as the basis of practice, laid down in the beginning of the Carpenter's Guide, I earnestly recommend to be well understood by every one who wishes to attain to eminence and accuracy in the profession; for whoever shall attempt the practical parts of the Carpenter's business without a due knowledge of the principles, will be like a ship at sea without rudder or compass, the port may be obtained, but the labour will be great and the event doubtful.

My endeavour has been to give articles of absolute use only, for as to a number of curious speculations which rarely come into practice, I see no end to inventing them; and I must say, that from my professional habits of teaching, I am but too well qualified to judge of the deficiency of young workmen, arising from defect of education, or from just principles having never been laid before them.

On that subtle subject, the proportional Strength of Timber, on which I gave some observations and calculations in my Carpenter's Guide, I was in hopes that I should have been able to reduce the theory of scantlings to an arithmetical

P R E F A C E.

v

arithmetical rule, of consequence certain, and of general application; I have to lament that all my endeavours, assisted by several gentlemen well versed in mathematics, have hitherto been unsuccessful.—As the best substitute for a just rule for proportioning scantlings, I have subjoined examples of roofs of the best repute, with accurate measurements to the parts; some of these having stood the test of time, are entitled to great credit as examples; of these, the roof of St. Paul's Cathedral must certainly stand foremost, as well for magnitude as merit; of the others, some parts may justly be considered as beacons of caution, the dangers of which I have endeavoured to point out: of the more modern ones I have to observe, their magnitude call them into important notice, and from the principles on which they are constructed, I see no reason to doubt their durability. I beg leave here to return my thanks to the several Gentlemen who have favoured me with communications for this part of my work.

The roofs which I measured I have the satisfaction to say, were all in good repair and free from any cracks or flaws arising from unnecessary thrusts or transverse strains; nevertheless, these examples should not be followed without caution and consideration, as it is possible a roof may be too strong or heavy, as well as too weak; there are certain positions in which if the timbers are fixed, the number of braces may be lessened, and the scantling of the timbers be much reduced; which will occasion less stress upon the walls, and greatly lessen the expence of the work; nor should we ever despair of making advances in science.

Connected with Roofs are the subjects Mortices, Tenons, King-posts, Iron-straps, and Joggles for braces or struts, on which the practical Carpenter will find much useful information, tending to point out the construction, best adapted to their several circumstances.

As the Strength of Timber is to all practical Carpenters a subject of the first magnitude, at the conclusion of this work the reader will find much very important and useful information relative thereto, extracted from the works of the most celebrated mathematician and philosophers who have written on the subject; these principally are Frenchmen, and when I name M. Belidor, M. du Hamel, and M. de Buffon, nothing more need be said, only that their researches were aided by the liberality of the old French Government; for ample funds and apparatus, with the whole of the forests in France, were at their command, properly to investigate and to experiment this important branch of science: other great names are quoted, and upon the whole I have

much reason to hope, this part of my labours will be productive of much good to my countrymen and of praise to myself.

And here it is but justice to make my acknowledgments to the *Encyclopædia Britannica*, where, under the article *Strength of Material*, an ample discussion of this subject will be found, with all the mathematical demonstrations necessary to the subject; forming a complete history of the researches which have been made by the various mathematicians and philosophers of Europe on this interesting subject.

To conclude, I have to hope, that what has been accumulated with no small portion of labour and pains to me, will be attended with a corresponding benefit to the Public, this only will give an impetus sufficient to carry me on in this intricate path of practical science.

PETER NICHOLSON.

P. S. I beg leave here to observe, as the information may have its uses, that upon enquiry I find the domical roof in my *Carpenter's Guide*, Plate 48, to be nearly alike in construction with the roof of the dome of the Pantheon, in Oxford-street, as originally executed by Mr. JAMES WYATT, Architect; also, that the roof, Plate 43, of the same work, is nearly similar to the one executed by that gentleman, over the stage, when the Pantheon was converted into an Opera-house.



CONTENTS.

CONTENTS.

	PLATE
S OFFITS, to draw the covering of an oblique cone —	1
— to draw a soffit fluing from the plan and level at the crown, when both the outside and inside arches are elliptical — —	2
GROINS , to draw and fix the ribs of a plaister groin whose plan is rectangular, and the arches to intersect each other at their common height —	3
— to draw and fix the ribs of a Welch groin —	4
ARCHES FOR MASONRY , to find the points of an elliptical stone arch cutting oblique in a straight wall, &c. — —	5, 6, 7
FLOORS , Section, plan with the girders, plan of a double floor —	8
— Plans and elevations with sections, shewing the bond-timbers in the wall, and the manner of framing — —	9
PARTITIONS , trussed partition, with two doors in it —	10
ROOFS , to find the strongest possible roof out of a given quantity of timber —	11
— to make a roof when the plan is a trapezium —	12
— to fix and describe the ribs in a dome, when the plan is a circle and the elevation a segment of a circle — —	13
— to cover the whole of a spheroidical dome with one mould only, when the plan is a section, passing through the transverse axis of the spheroid, &c. —	14
— to cover a spheroidical dome with boards, having all their joints in plains, perpendicular to the transverse axis of the dome. —	15
— to fix a conical top over a square room —	16
— to determine the intersections of a conical finish over any square room, the diameter being equal to the diagonal of the square —	17
— to fix the ribs of a spandrel dome standing over a square plan —	18
— to find the intersection of the ribs of a spandrel dome, &c. as plate 17. —	19
SKY-LIGHTS , to place the ribs of a conical sky-light, so that their distances shall be proportional to the degree of curveture of the plan, &c. —	20
— to draw the curb of a conical sky-light placed on the inclined side of a roof, &c. —	21
NICHES to draw the ribs for the top of a niche, the head being a semicircle, and the plan a segment —	22
— to find the ribs of a spherical niche which is the segment of a circle on the plan, and a semicircle on the elevation —	23

NICHES

CONTENTS.

	PLATE
NICHES to describe the ribs of a niche when parallel to each other, whose top is part of a globe, &c.	— 24
To draw and fix the ribs of a circular niche in a circular wall	— 25
Of FIXING GROUNDS.	
Of LAYING FLOORS.	
MITERING	— 26
Of TAKING DIMENSIONS	— 27
HINGEING, the principles of hanging doors, &c.	— 28
Of PLACING HINGES	29 to 33
Of DOORS, method of making double margin	— 34
Of HANGING DOORS.	
— to find the true bevel for hanging—to find the joints for folding	— 35
— to find the bevel on the edge, when on a circular plan, to turn on the convex side	— 36
— to find the meeting joint of folding-doors, when the hinges are on the concave side	— 37
Of DOORS, elevation and section of folding-doors, to open a communication, &c.	38
— section of the above, showing the construction, &c.	— 39
— elevation of folding-doors, to shut quite out of the way, to open a communication, &c.	— 40
— elevation of a jib door	— 41
— of constructing the base-mouldings of a jib-door, by a circular motion in the joints	— 42
— to find the joint of a jib-door, the joint to be a plain	— 43
— to hang folding-doors, so as to open or shut together, called Sympathetic-doors	44
SASH FRAMES, the construction	— 45
SASH SILLS and SASHES	— 46
SHUTTERS, the construction	— 47
— elevation and plan of a window, when the wall is not thick enough to admit of boxing	— 48
— section of the above	— 49
— plan, &c. as before, and to shew the same finishings as if there were boxes	50
— different section of ditto	— 51
— plan, &c. of shutters, which will show uniform whether the shutters are open or shut	— 52
— parts of the foregoing at large	— 53
— when the frame is out of the square, &c.	— 54
— plan and elevation of shutters to the foregoing example	— 55
Of DIMINISHING AND ENLARGING Mouldings, &c.	— 56
Of RAKING MOULDINGS straight or circular	— 57
Of SETTING OUT SHOP FRONTS on a circular plan	— 58
	STAIR-

CONTENTS.

xi

	PLATE
STAIR-CASES, to draw the scrole of a hand-rail to any number of revolutions	59
— to find the form of the veneers for glueing a rail in thickness	60
— to draw the elevation of a hand-rail and the ends of the steps for stairs, the well-hole being the frustum of a cone	61
— to find the falling mould to the above	62
MOULDS, to find the moulds for making a hand-rail in thickness, when the well-hole is the frustum of a cone	63
— the same continued	64
— to find the moulds for making butt-joints for a rail, when got out of the solid	65
Additional description to PLATE 29.	

EXAMPLES OF ROOFS WHICH ARE BUILT.

St. Paul's Cathedral	66, 67
St. Paul's Church, Covent Garden	68
Islington Church	69
St. Martin's Church	70
Chapel of Greenwich Hospital	71
Drury-Lane Theatre	72
Birmingham Theatre	73
Tower of the York-Buildings Water-Works	74
Design for a Spire and for a Turret	75
Of TENONS AND MORTICES, according to their position	76
Of IRON STRAPS AND KING POSTS	77, 78, 79

	PAGE
Of THE STRENGTH OF TIMBER	69
Belidor's Experiments	70
Buffon's ditto	71
Du Hamel's ditto	74
Of the absolute Strength of Timber	74
Practical Observations	75
To cut the strongest possible Beam, out of a round Tree	76
Conclusion	77
Additional Description to PLATE LXXIX	79

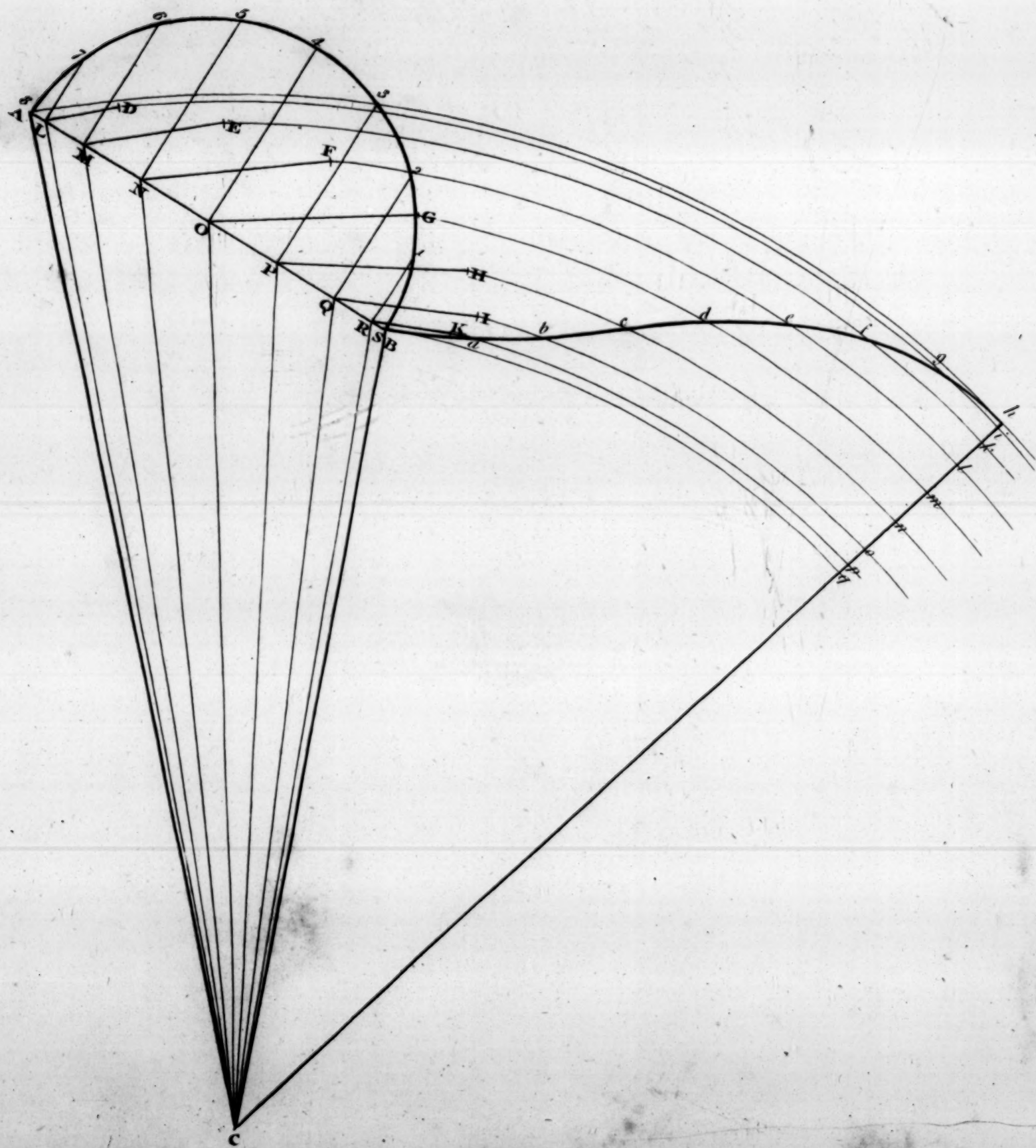
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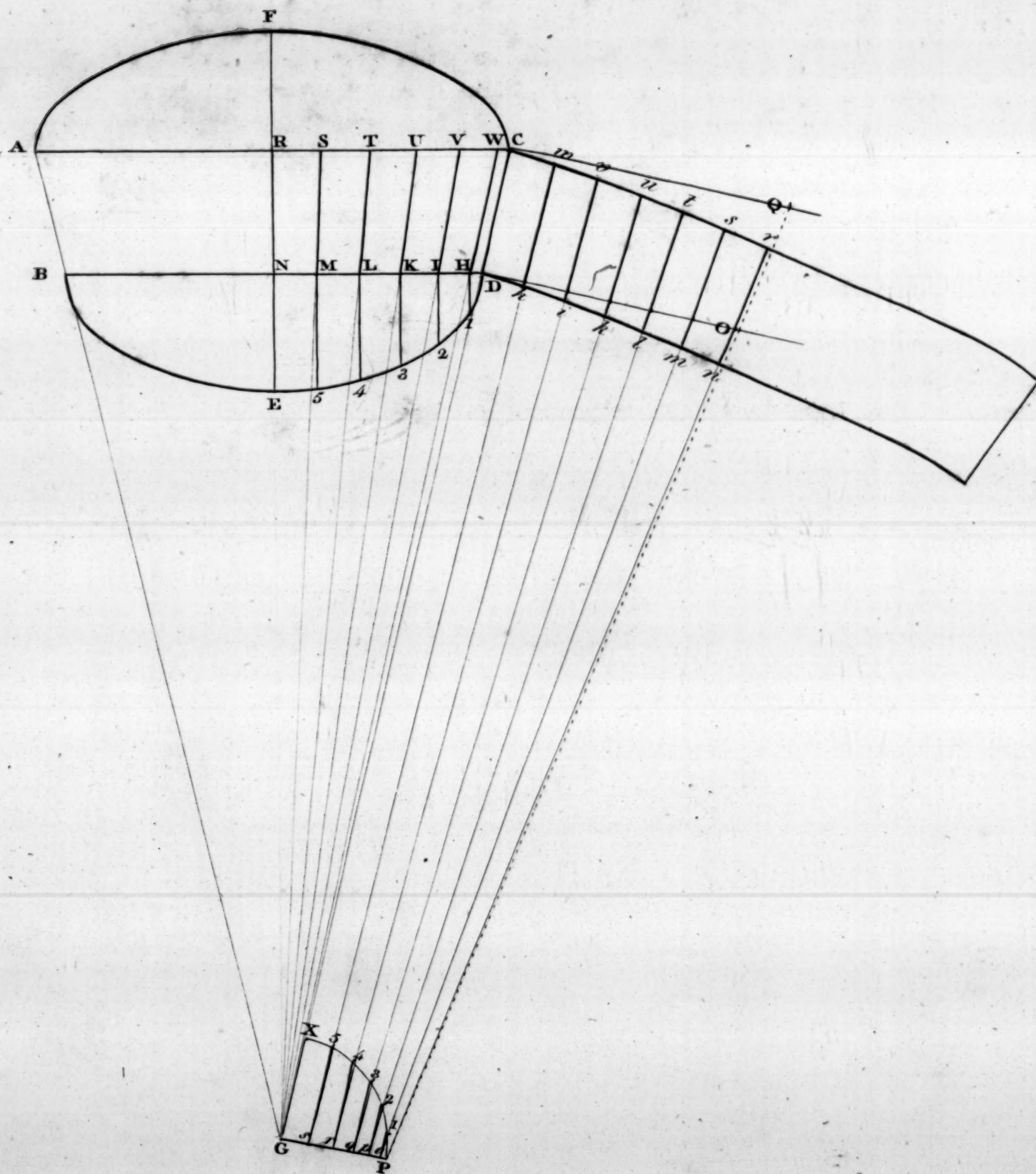


Soffit

Pl. 7.







THE
CARPENTER AND JOINER'S ASSISTANT.

EXPLANATIONS, &c.

PLATE I.

SOFFITS.

To draw the covering of an oblique cone.

LET ABC be the most oblique section of the cone through its axis, and $B\ 1\ 2\ 3\ 4\ 5$, &c. be the base for half the cone, divide it into any number of equal parts at the points $1\ 2\ 3\ 4$, &c. through these points draw, $1\ R$, $2\ Q$, $3\ P$, $4\ O$, &c.; perpendicular to AB join CR , CQ , CP , CO , &c.; then draw RK , QI , PH , OG , &c. respectively perpendicular to CR , CQ , CP , CO , &c. and respectively equal to $R\ 1$, $Q\ 2$, $P\ 3$, $O\ 4$, &c. through the points B , K , I , H , G , F , &c. describe the arcs s , $B\ g$, $K\ p$, to $H\ n$, $G\ m$, &c. Then take any of the equal parts, as from B to 1 , or from 1 to 2 , round the semicircle; put one foot of the compass in B cross the next arc at a , then put one foot in a cross the next in b , then put one foot in b cross the next in c ; and in this manner proceed through all the points, till you arrive at b the last point; then will $B\ a\ b\ c\ d\ e\ f\ g\ h\ C$, be the edge of the covering of the half cone.

PLATE II.

SOFFITS.

How to draw a soffit rising from the plan and level at the crown when both the outside and inside arches are elliptical.

Let $ABDC$ be the plan of a door or window having a soffit of this nature, and let AFC , BED , be the outside and inside arches, divide half of the arch DEB , as $D\ 1\ 2\ 3\ 4\ 5\ E$ into any number of equal parts, as six, and produce AB and CD , the
B two

two sides of the plan, till they meet in G ; from the points C , D and G , draw the lines CQ , DO , and GP , perpendicular to CG ; make DO and CQ respectively equal to the arc, DE and CF ; through the points Q and O draw the line QOP , cutting GP in P on G ; with the radius GP describe the quadrant PX , divide the arc PX into as many equal parts as the arc DE is divided into at; 1, 2, 3, 4, 5, draw lines $5s$, $4r$, $3q$, &c. parallel to XG , cutting GP at s , r , q , p , and o , take the distance GH , from s describe an arc at h , take the distance between $D1$ or 1 and 2 on the arc DE , then on D cross the former arc at h , then take GI , on r , describe an arc at i , then with the same distance as before, viz. between $D1$ or 1 and 2, on h describe an arc cutting the former at i ; then take GK , and on q describe an arc at k ; then again, with the distance $D1$ on i , cross the arc k at k . Proceed in this manner to find the points l , m , and n , then will the points D , h , i , k , l , m , and n , coincide respectively on the arch at $D1$, 2, 3, 4, 5, and E , which will give one half of the curve for the arch DEF , the points C , w , v , u , t , s , r , to cover the arch CF will be found by making hw , iv , ku , lt , ms , and nr , equal to their corresponding distance HW , IV , KU , LT , MS , and NR ; a curve being traced through these points will give one half of the soffit, from this a mould may be made that will give the other half.

PLATE III.

GROINS.

How to draw and fix the ribs of a plaster groin whose plan is rectangular and the arches to intersect each other at their common height.

Let $GHIKLM$ be one of the arches given, standing over $ABCDEF$ on the plan, or in any other position parallel to it; let N , O , P , Q , R , S , be the piers on which the ribs are to stand.

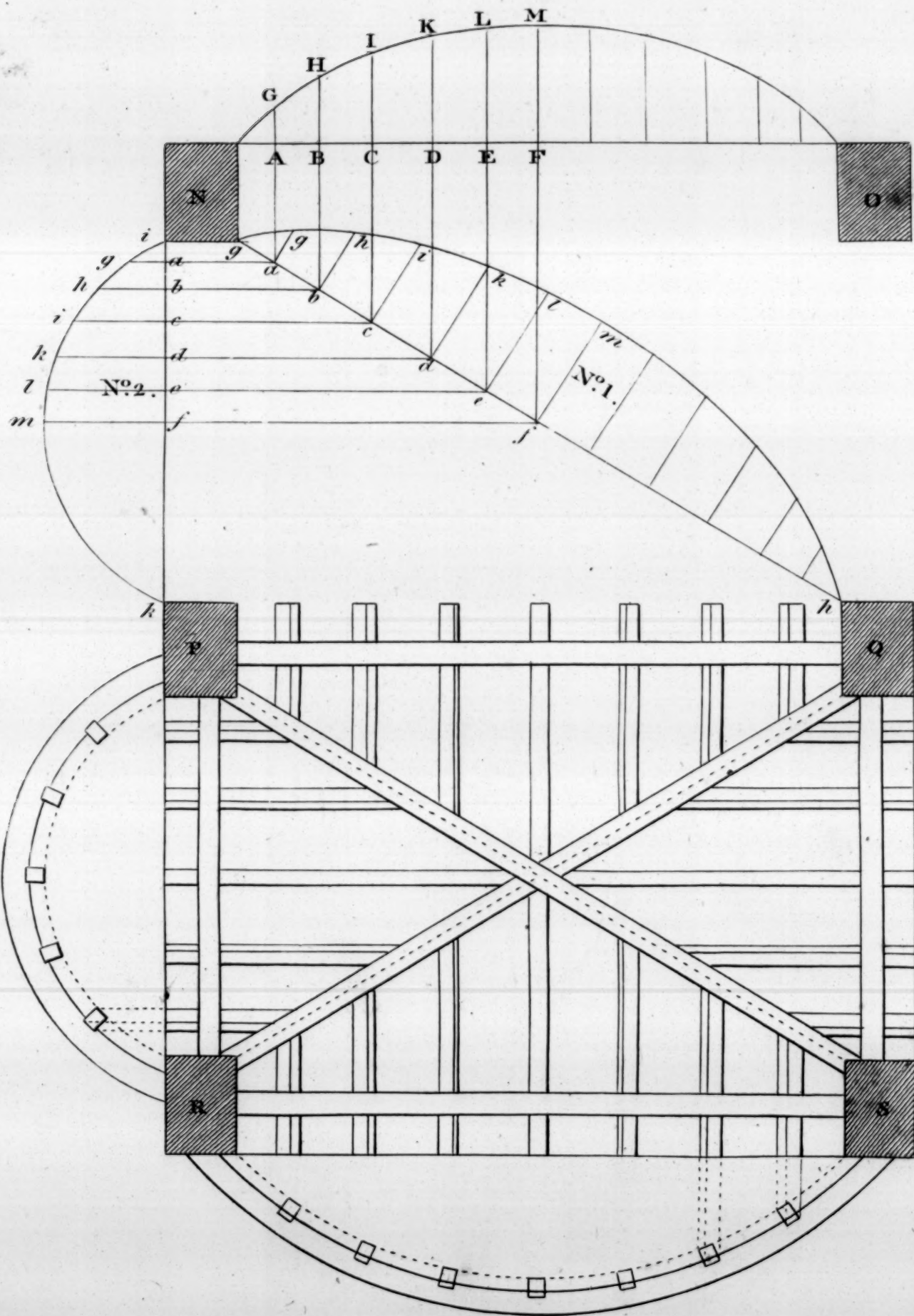
Take any points G , H , I , K , L , and M , at pleasure, from these points draw lines MFf , LEe , KDd , ICc , &c. perpendicular to the base $ABCDEF$, cutting the angular rib gh at the joints a , b , c , d , e , f ; from these points draw perpendiculars ag , bh , ci , dk , el , and fm , to gh ; also through the points a , b , c , d , and e , in gh No. 1, draw parallel lines to the other side of the groin aag , bbb , $ccci$, ddk , eel , and ffm , cutting ik at the points a , b , c , d , e , and f ; then make all the distances ag , bh , ci , dk , el , fm , in No. 1, and No. 2, equal to corresponding distances, AG , BH , CI , DK , EL , and FM , will be points in half of the arches at No. 1 and No. 2, from which the curve of the rib may be completed.

The fixing of the ribs of the groin may be as follows:

Put principal ribs across the piers each way, also across the diagonals; then put straight ribs across these parallel to each side of the groin, meeting on the diagonal rib in order to fix the laths.



PLATE







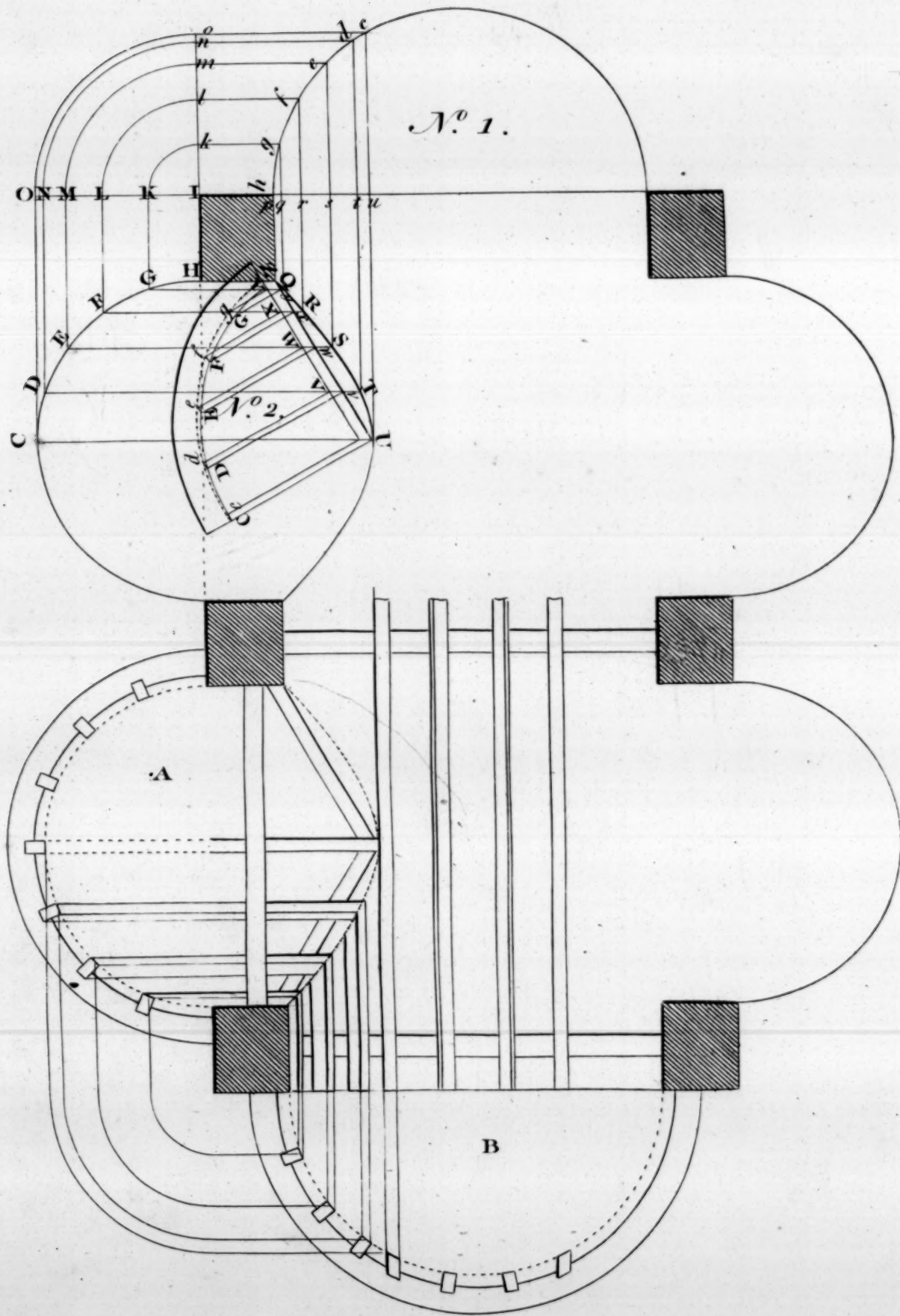


PLATE IV.

GROINS.

How to draw and fix the ribs of a Welsh groin by an easy method.

In order to have a correct idea of the manner of finding the lines of this groin, it will first be necessary to know the manner in which the ribs are to be fixed.

The rib over *B* is one of the body range, the rib at *A* is one of the side arches cutting under the former; the principal ribs are first fixed across the piers, then straight ribs may be notched across the under edge of the principal ones, so as to meet each other exactly at the intersection of the two sides of the groin.

How to describe an angle rib for this groin.

Divide the half arch *CDEFGH* into any number of parts at the points *D, E, F, G*, through these points draw the parallel lines *CO, DN, EM, FL*, &c. parallel to the body range of the groin cutting the other side of the groin produced, at *O, N, M, L, K*; then on *I* as a centre, with the distances *IK, IL, IM, IN*, and *IO*, as radii, describe the quadrants *Oo, Nn, Mm, Ll*, and *Kk*, cutting the side of the groin produced at *o, n, m, l, k*; through these points draw lines *oc, nd, me, lf*, &c. parallel to *OI*, cutting the body range at *c, d, e, f, g*; through these points draw parallels *cU, dT, eS, fR*, &c.; also through the points *C, D, E, F, G*, draw the parallels *CU, DF, ES*, &c. cutting the former at *U, T, S, R*, which will give the seat of the angle.

How to trace and back the angle rib.

From the angle of the pier at *N*, and the middle of the seat of the angle at *U*, join *NU*, cutting the lines *DT, ES, FR*, and *GQ*, at the points, *v, w, x*, and *y*; draw the line *zy* parallel to *UZ*, distant from each other the thickness of the rib, cutting *CU, DT, ES, FR*, and *GQ*, at *z, V, W, X, Y*; through the points *U, u, v, V, w, W, x, X, y, Y*, draw the perpendiculars *UC, uc, vD, VD, wE, We, xF, XF*; make *uc, Vd, We, Xf*, and *Yg*, on No. 2, respectively equal to *uc, td, se, rf*, and *qg*, and through the points *c, d, e, f, g, m*, No. 2, draw *Cc, Dd, Ee, Ff, Gg*, parallel to *UZ*, cutting *UC, TD, SE*, &c. at *D, E, F*, and *g*; then will *CDEFG* be one of the backing lines, and *cdefg* the other.

PLATE V.

ARCHES FOR MASONRY.

To find out the points of an elliptical stone arch cutting oblique in a straight wall.

Divide half of the arch BC perpendicular to AF , *fig. 1.* into any odd number of equal parts, two of which parts are supposed equal to the thickness of one of the stones on the under side of the arch; this is done so that there may be a stone in the middle of the arch, instead of a joint. Then the distances between 1, 2, 3, 4, 5, &c. contain each two parts. Find one half of the soffit at *fig. 3*, as is shown in the *Carpenter's New Guide*, *fig. A.* plate 2. Then will 1, 2, 3, &c., in *fig. 3*, be the moulds for the underside of the stones, at 1, 2, 3, &c. in *fig. 1*; the widths of the moulds at No. 1, No. 2, No. 3, &c. are respectively equal to CL , 1 a , 2 b , 3 c , &c. in *fig. 1*. Then the rhomboides E, M, G, L , will be a mould for the joint CL , it will be enough to describe any one of the joints. Suppose 7 g at *fig. 1*, draw ge perpendicular to AC , cutting DE , at e , and 7, 5 m , parallel to it; from e , draw $e5$ perpendicular to ge , then take the distance 5 m , in *fig. 1*, and set it from 7 to m , at No. 7, draw 7 g perpendicular to it, equal to 7 g at No. 1, join mg in No. 7, continue $m7$ to h , make mh , at No. 7, equal to EM , at *fig. 1*, then complete the parallelogram, $mgih$, will be a mould for the joint 7 g , at No. 1.

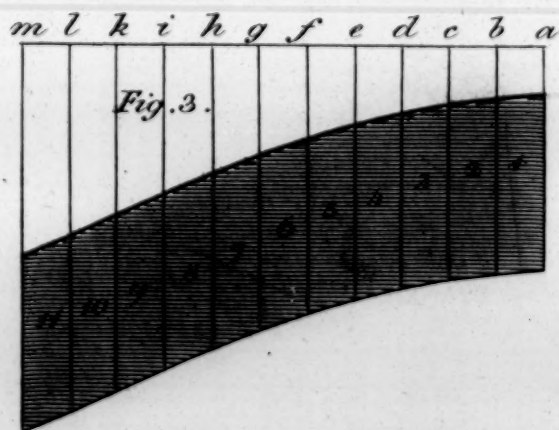
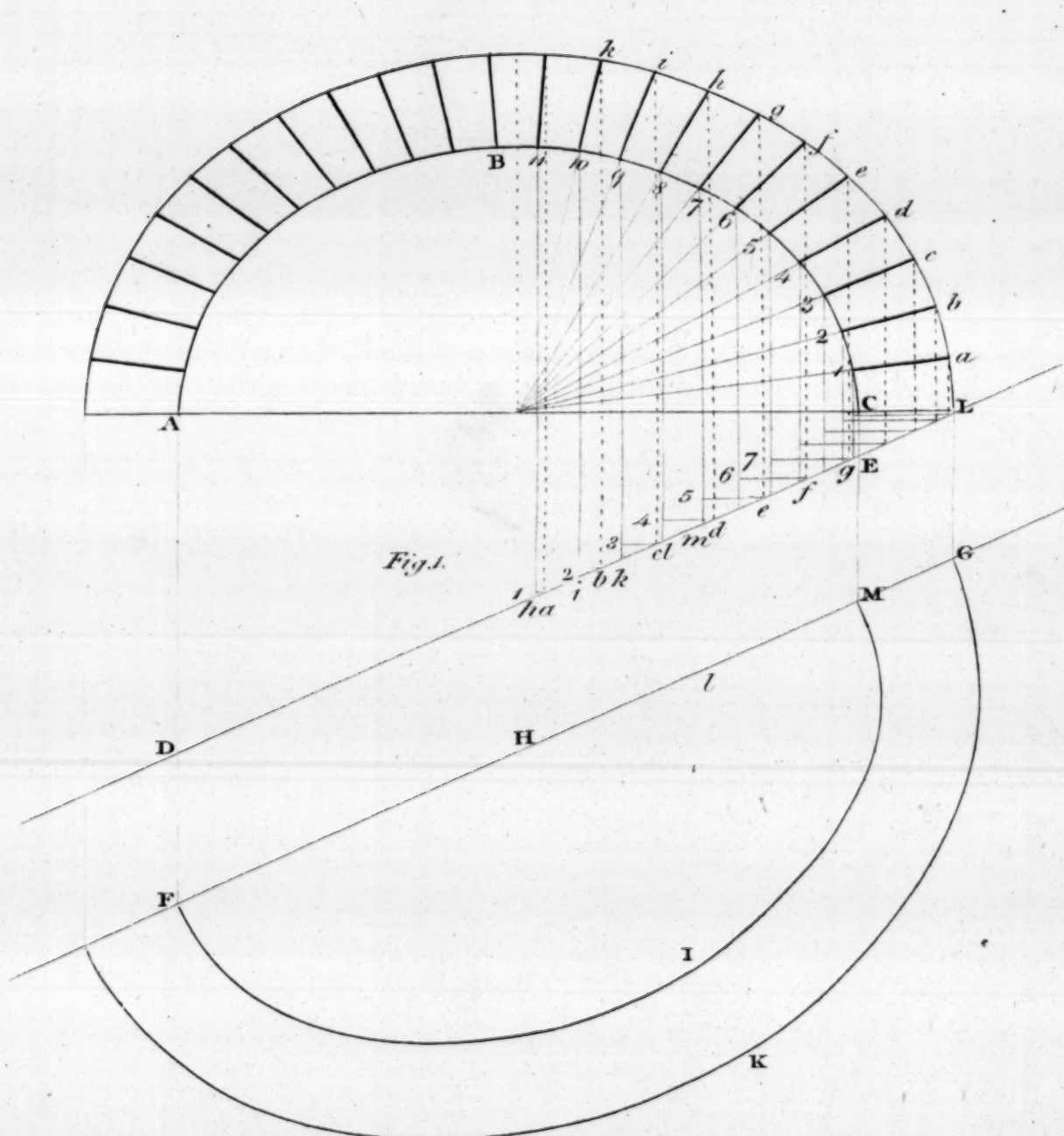
PLATE VI.

ARCHES FOR MASONRY.

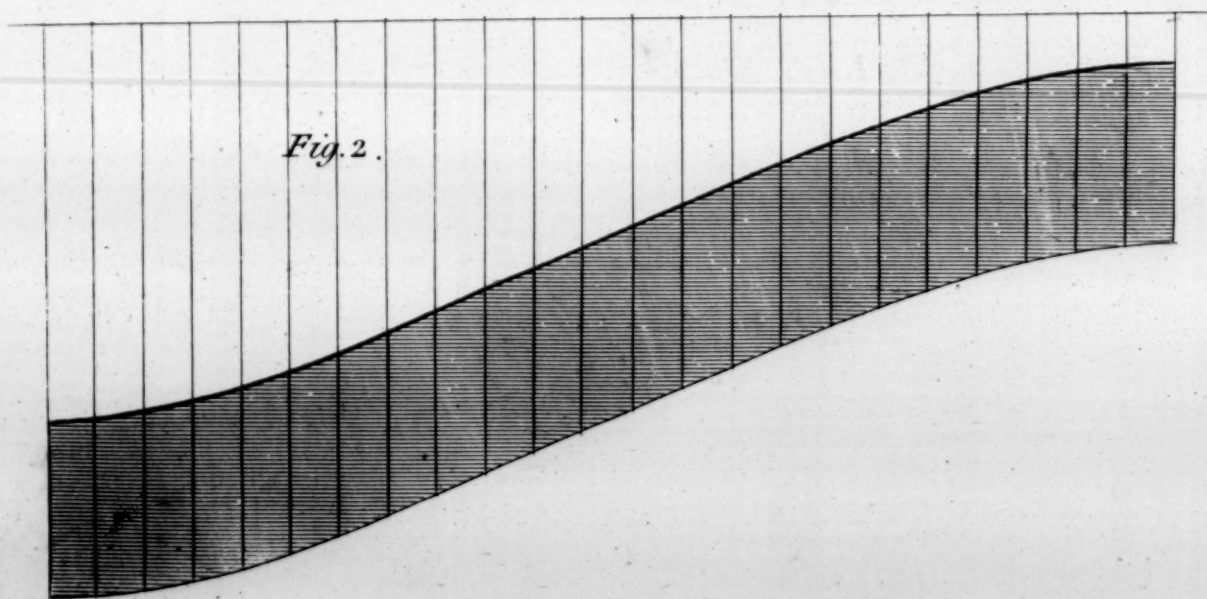
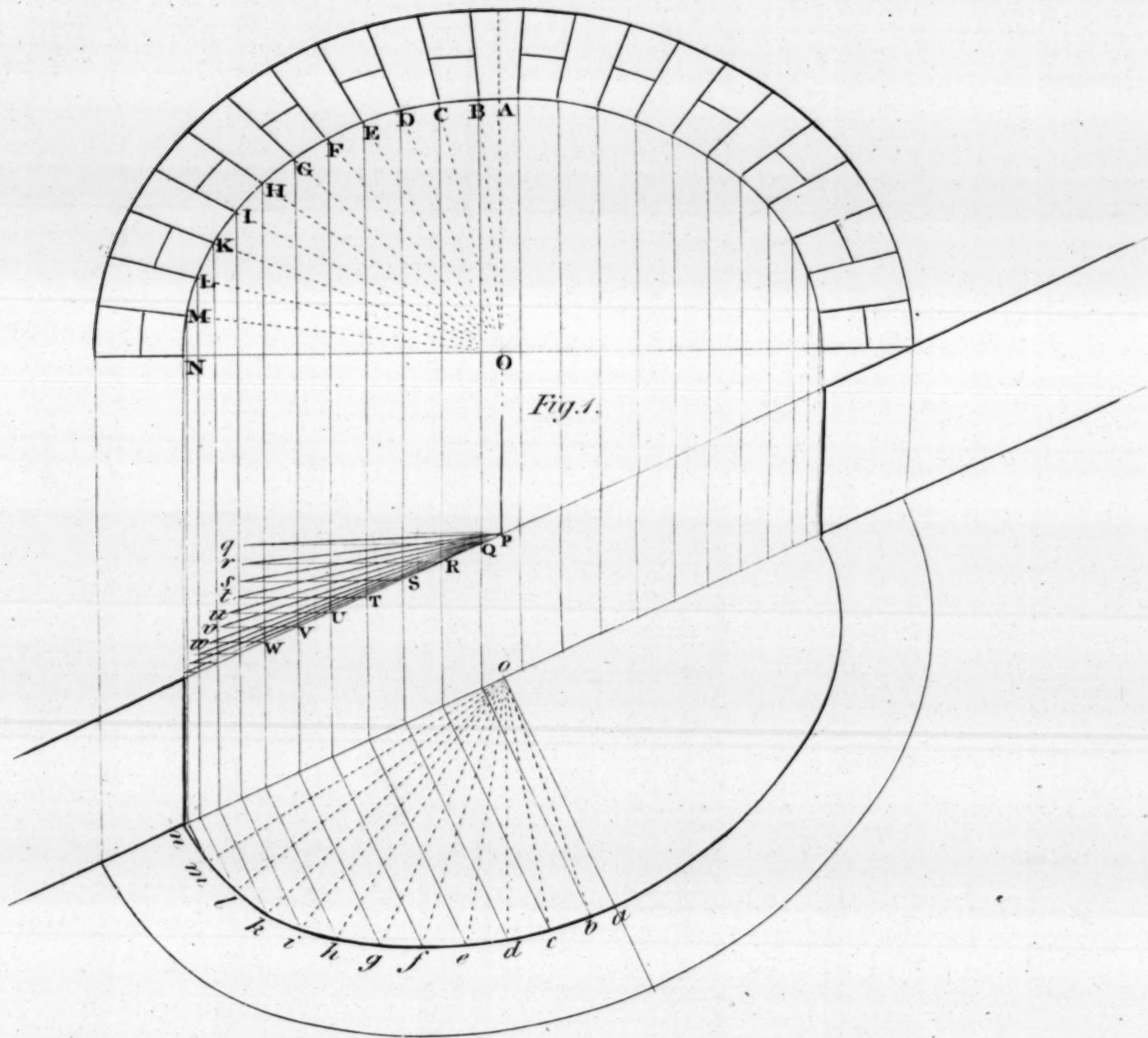
In plate 5. has already been shewn the method for finding the lines of an elliptical arch, cutting obliquely into a straight wall, by a general method which may be applied to circular walls; but in this I shall shew a more particular rule which will be shorter in practice for this kind of arch.

First find the soffit as in *fig. 2*, for the underside of the arch; now in order to find the levels of the side joints, at B, C, D, E, F, G , &c. draw parallels BQ, CR, DS, ET , &c. cutting the face of the wall at Q, R, S, T , &c.; from these points draw the perpendiculars Qq, Rr, Ss, Tt , &c. to the lines BQ, CR , &c.; take Ob , on P , cross the perpendicular Qq , at q , draw pq , then take oc , on P , cross Rr at r , and join Pr ; take od on P , cross Ss at s , join Ps ; in this manner proceed to find all the other lines Pt, Pu, Pv, Pw , &c. then will Pq, Pr, Ps , &c. make angles with the line OP , which the end of each joint must make with the underside respectively at the joints B, C, D, E, F , &c.

PLATE











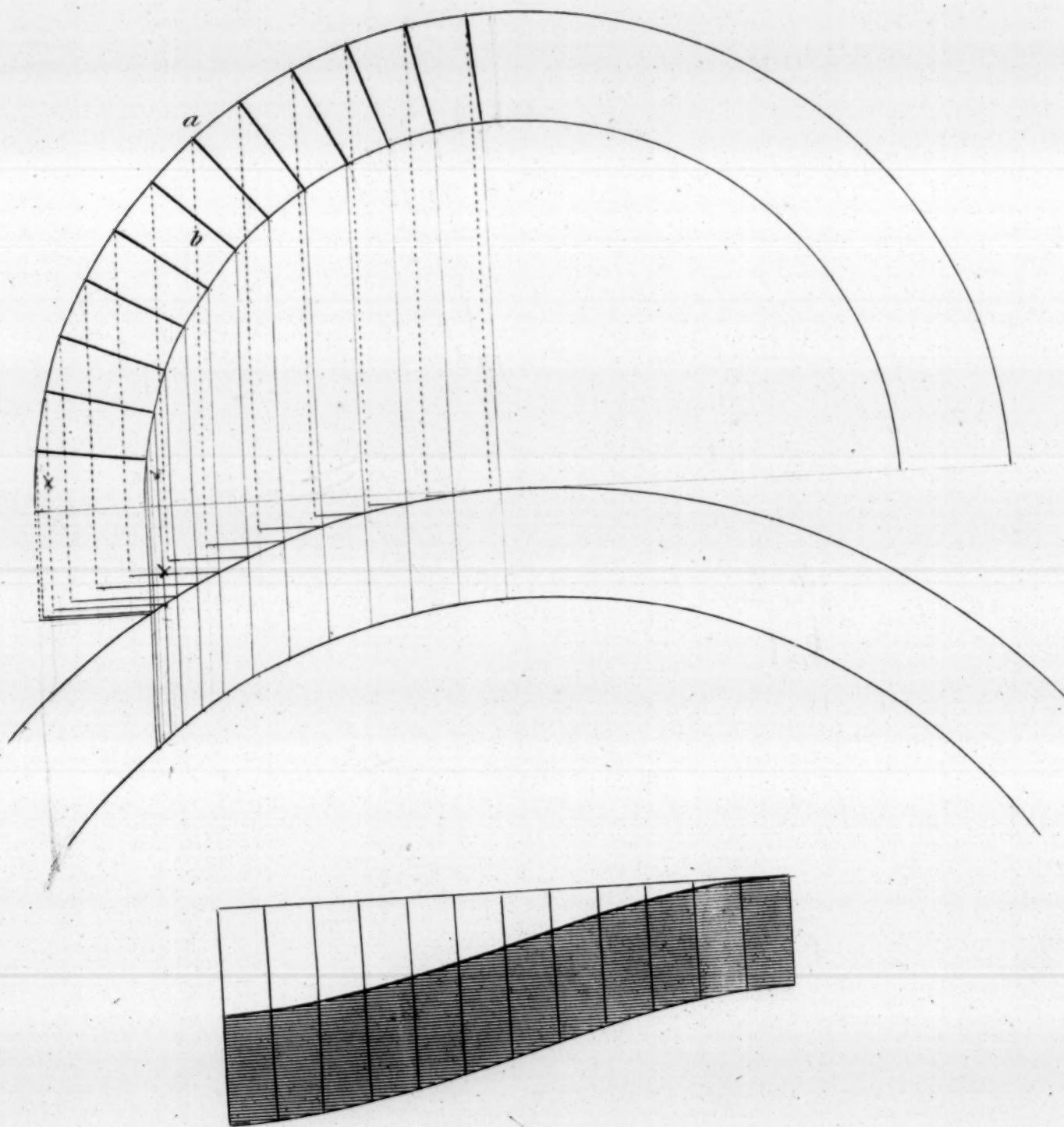
Arch for Masonry



Fig. 2. Floors.

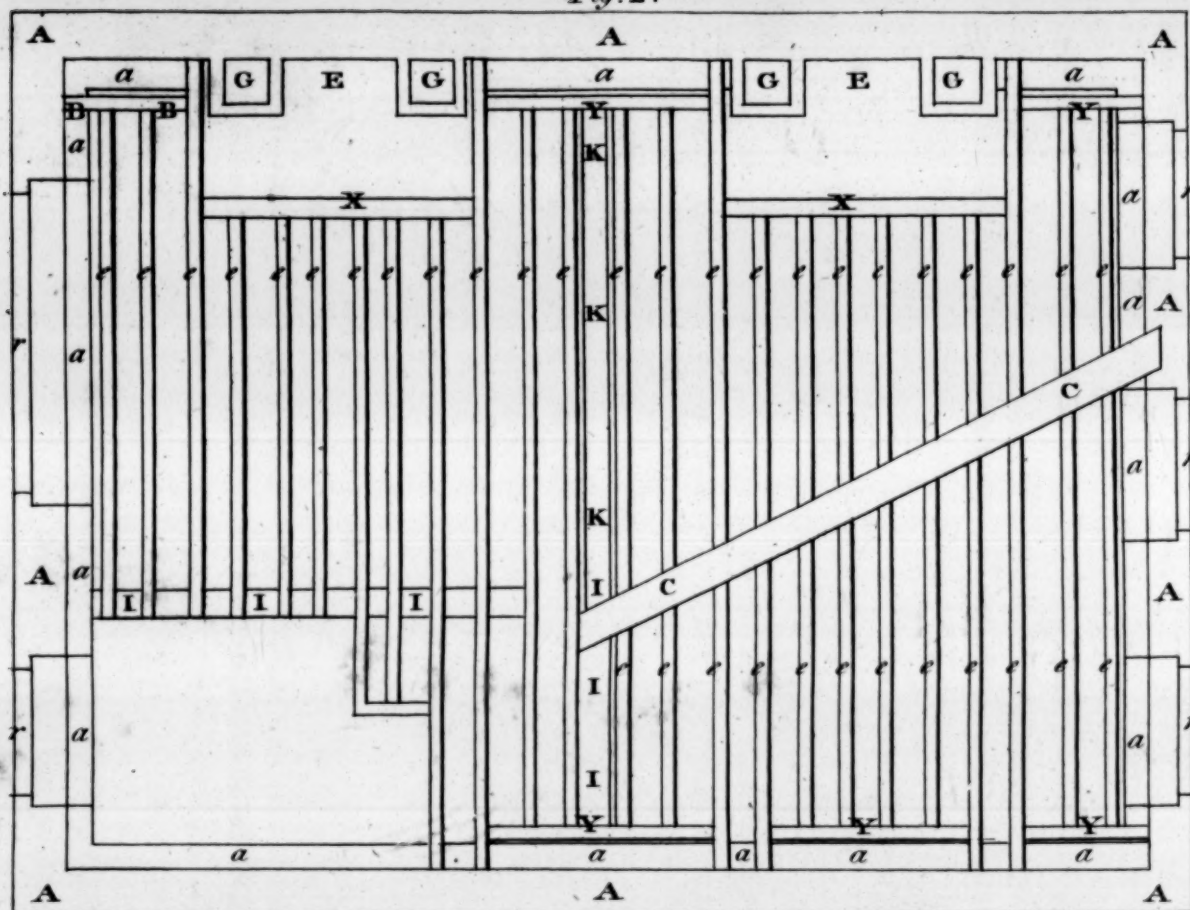


Fig. 3.

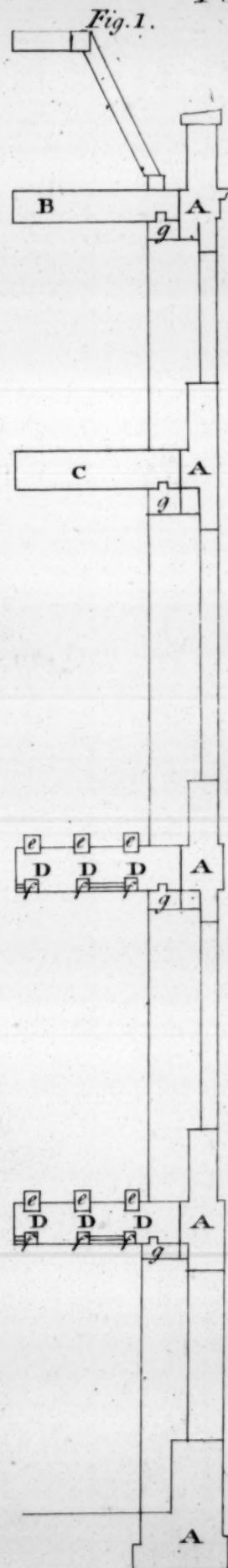
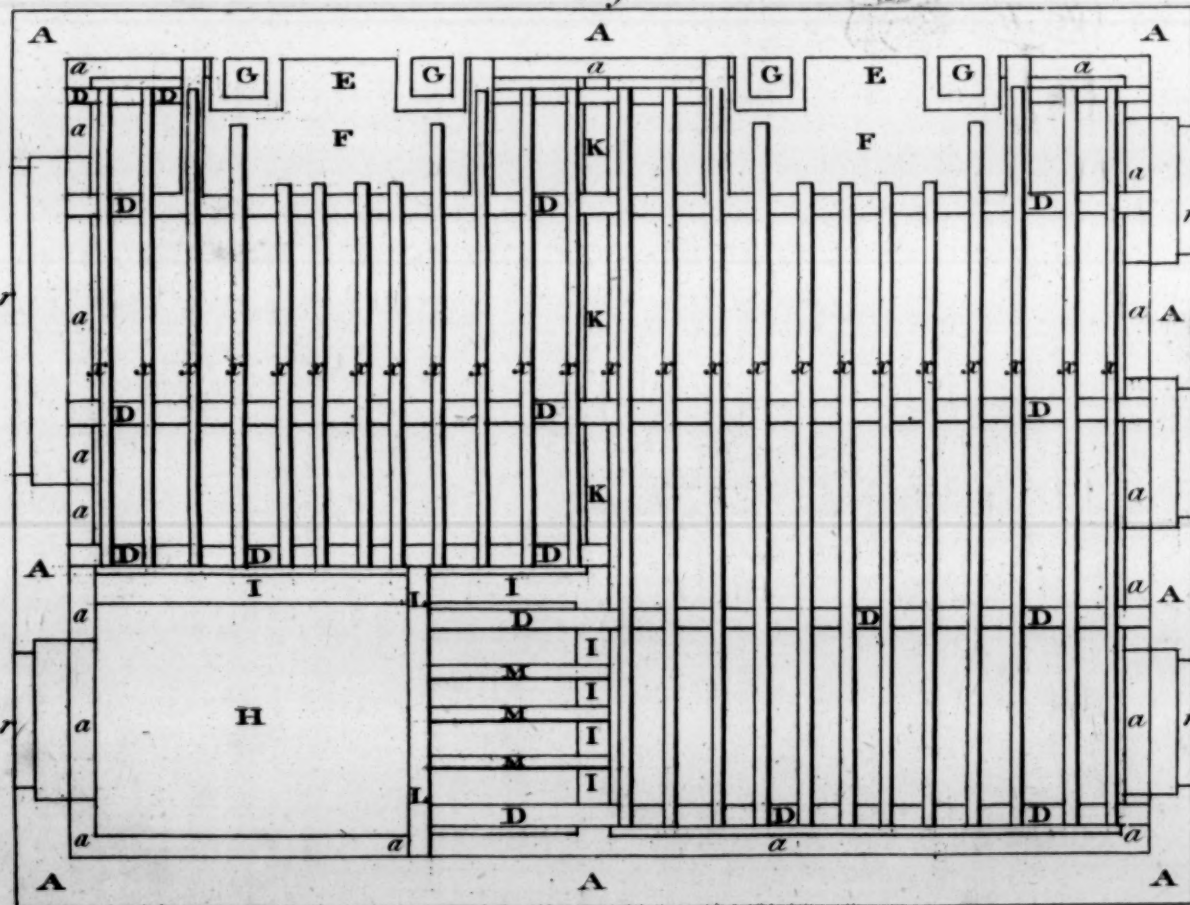


PLATE VII.

ARCHES FOR MASONRY.

Of a stone arch in a circular wall.

The description of this arch is similar to that of the elliptical arch, cutting obliquely into a straight wall, as has already been described in plate 5. That is, the moulds for the underside of the stones and the joints will be found, as in that plate; but the fronts of the stones must be wrought circular to the plan, or perpendicular, on the elevation; therefore in order to bring the face of each stone, forming the arch, to the true curve of the wall, a straight edge applied to the face of each stone, which must be in a direction which would be perpendicular when put in its place, which line may be found as follows: from the elevation draw a perpendicular line *a b*, cutting the top of the joint of the stone at *a*, and the side at *b*, then the stone being wrought on four sides, the face will be easily wrought by keeping the straight edge always parallel to *a b*.

PLATE VIII.

OF FLOORS.

FIG. 1, the perpendicular section of a house through the windows.

A A A A A, section of the walls through the windows.

B, tie beam.

g g g g, &c. the wall plates, on which rests the tie beams, girders and binding joists.

C, a girder cocked down to the wall plate *g*.

D D D, binding joists in the floors.

e, e, e, are the ends of the bridging joists, running over the binding joists.

f, f, f, the ends of the cieling joists which are chased at one end in the binding joists.

FIG. 2. *The plan of a floor with a girder, shewing how to place the same.*

No girder, or strong tie, should be placed over any opening, and as the best method of laying girders, is to have them exactly in the middle of the room and parallel to the walls on each side; but as this is not always practicable, as in the present example, there being an opening, or window, in the middle of the room; therefore, that the girder may divide the

the room, as near as possible, into two equal parts, let the one end of the girder rest upon the pier that is nearest to the middle, and the other at the same distance on the contrary side in the opposite wall.

AAAA, &c. plan of the walls.

GGGG, the flues.

r, r, r, r, r, thickness of the brick work, from the outside of the fash frame to the outside of the wall.

a, a, a, a, a, &c. plan of the wall plates.

C, C, the girder.

e, e, e, e, e, &c. the joists framed into the girder *C* and into the tail-trimmers *Y, Y, Y*, &c.

Y, Y, Y, Y, &c. tail-trimmers, in order to prevent the ends of the timbers, as much as possible, from going into the wall; according to the regulations of the building act.

X, X, hearth trimmers.

K, K, K, a six inch partition between the rooms.

IIIIII, a nine inch wall enclosing the stairs.

FIG. 3. *Plan of a double floor.*

In this the same letters refer to the same things as in *fig. 2*.

DDDD, DDD, DDD, &c. binding joists, their sides are shewn at *DDD*, in *fig. 1*.

x, x, x, x, &c. bridging joists.

L L, the stair-trimmer.

M, M, M, single joists framed into the stair trimmer, *L L*.

PLATE IX.

OF FLOORS.

No. 1. *Plan and two elevations, with sections, of naked flooring and walls, shewing how to construct the bond timbers in the wall, also the manner of framing the floors for small buildings, or buildings of the third or fourth class.*

Plan of the flooring.

BBBBBB, plan, or a horizontal section of the brick work.

C, C, windows.

D, chimney.

E, flue.

F, door.

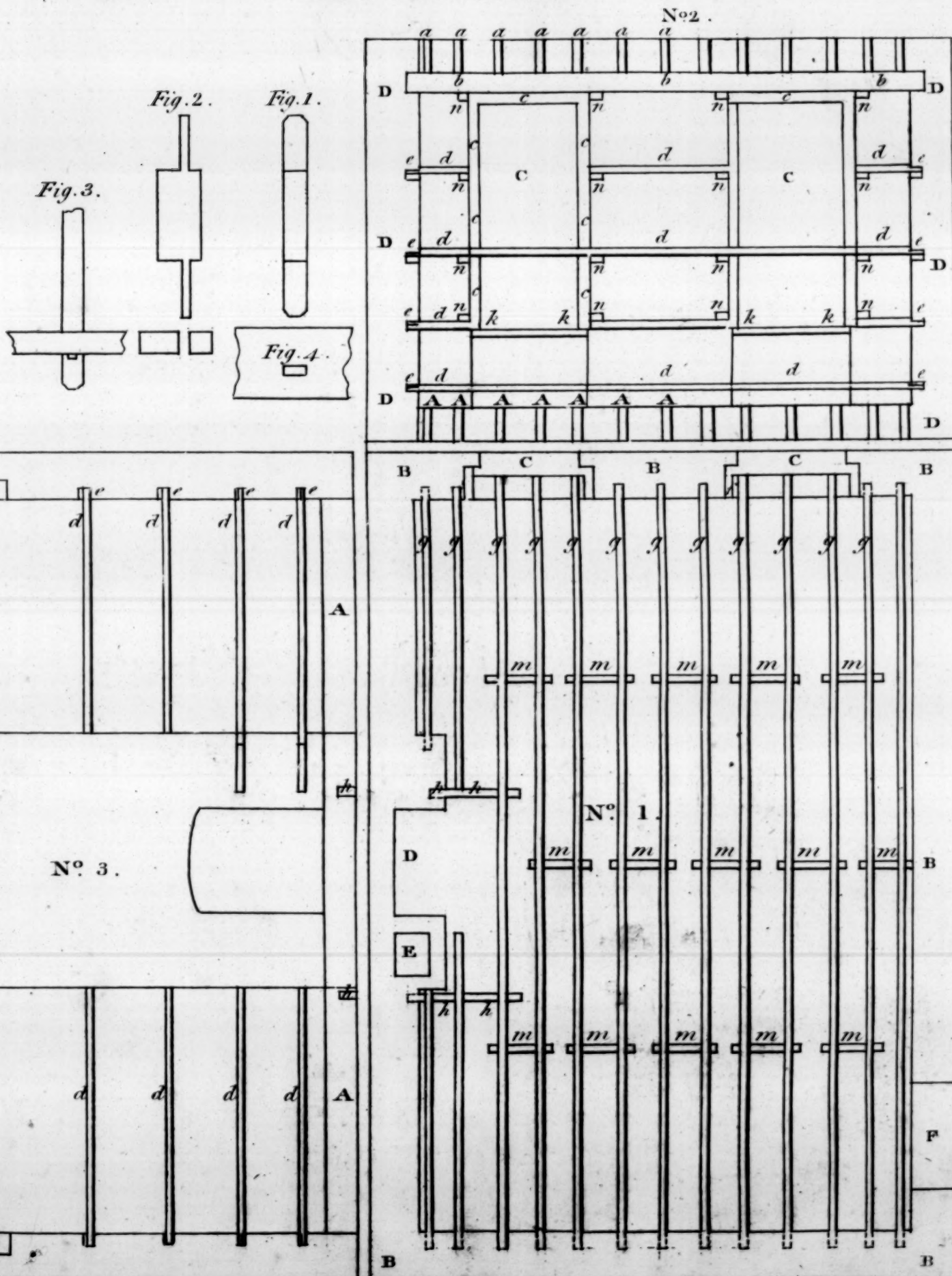
g g g g, &c. common joists.

h h h h, trimmer joists framed into the common joists.

m m m m, &c. keys to strengthen the joists. *Fig. 1*. shews the edge or top of a key.

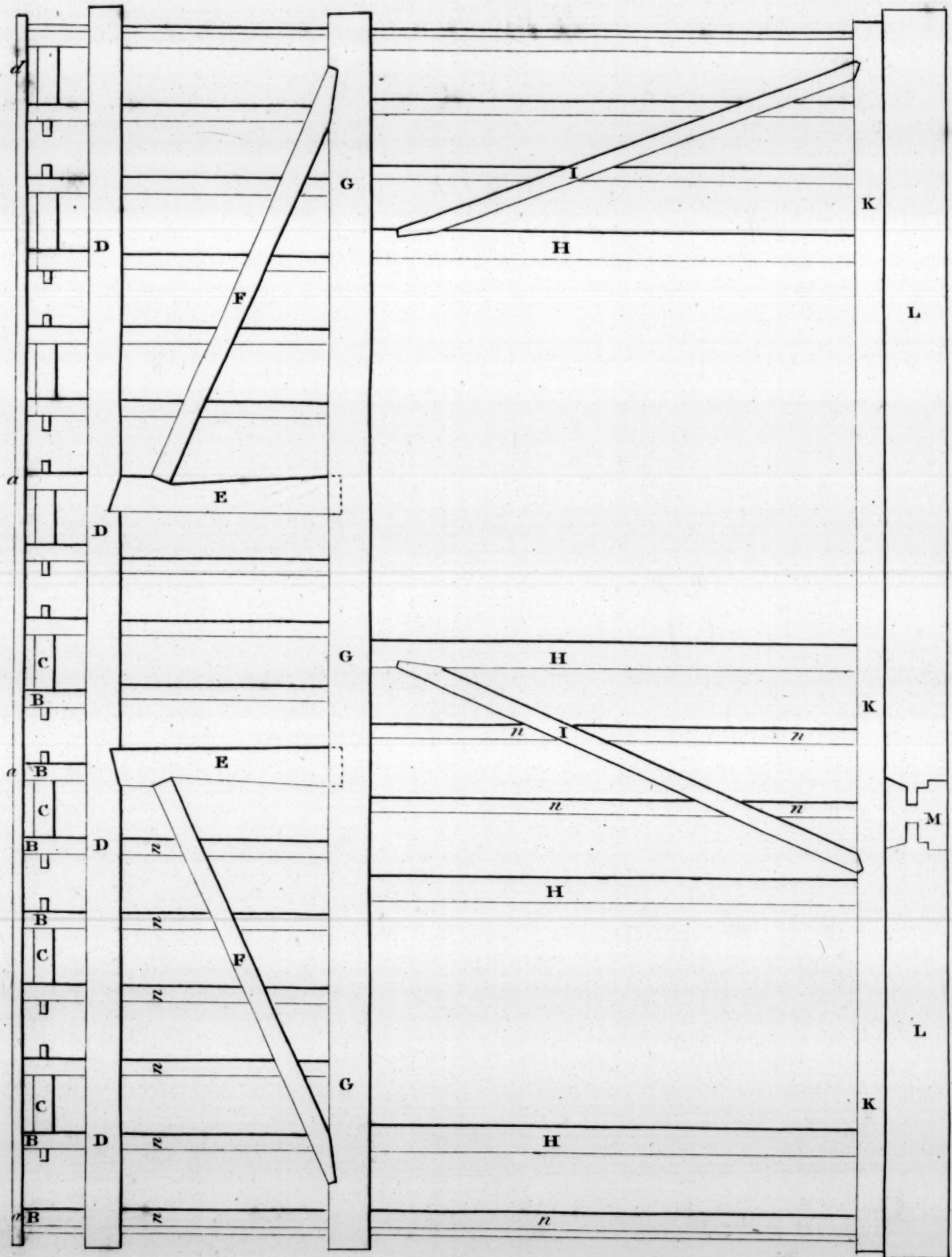
Fig. 2. the side of ditto. *Fig. 3*. a key framed into the joist. *Fig. 4*. side view of a joist, shewing the mortise to receive the key.

No.









THE CARPENTER AND JOINER'S ASSISTANT.

7

No. 2. *Elevation of the window side of the room.*

C, C, windows.

c c c c, &c. the breadth of the recessed part of the window.

k k, bond timbers under the window.

a a a a, &c. the ends of the joists of the floor above the windows.

b b b, a wall plate for the joists.

d d d and *d d d*, bond timbers in the wall.

e, e, e, e, &c. the ends of the bond timber in the side walls.

n, n, n, n, &c. the ends of the bond timber from the recess of the windows.

A A A A, the joists of the floor, below the window.

No. 3. *Elevation of the chimney side of the room.*

The letters of reference are the same as to No. 2.

PLATE X.

TRUSSED PARTITIONS.

Design for a trussed partition, with door-ways in it.

B, B, B, B, B, &c. the ends of the joists of the floor, above the partition.

C, C, C, C, keys put between the steady joists, when they have a long bearing, and to strengthen the floor.

a a a a, thickness of the floor.

D D D D, top of the partition.

E, E, queen posts.

F, F, braces, to keep the building steady.

G G G, lintle-piece over the doors.

H, H, H, door posts.

I, I, braces for the lower partition.

K K K, bottom of the partition.

L, L, joists going into the girder *M*.

M, the girder shewing the tenons.

n, n, n, n, &c. are upright quarterings.

PLATE

PLATE XI.

OF ROOFS.

The width of a roof being given, and the quantity of timber to make it, to find the height so that it shall be the strongest possible.

FIG. 1. Let AB be the width, or span, between the principal rafters: on it describe a semicircle, $AdeB$; divide AB into three equal parts at the points a and b ; from these points draw the perpendiculars ad and be , cutting the circle in d and e , join Ae and dB , cutting each other at the point C ; then will CA and CB , be the upper edge of the principal rafters, which will also constitute the height of the roof.

FIG. 2. is a design for another roof, made on the same construction, for a smaller span.

Names of the timbers.

AB , the tie beam.

CL , the king post mortised and bolted into the tie beam at L . See also No 1.

II , braces mortised into the king post.

AC and CB , are principal rafters mortised into the tie beam, at A and B , (see No. 6.) and into the king post at C , and also into the braces.

G, G , sections of the wall plates, which are let into the tie beam in order to bind the walls of the building together. (See No. 5, 6.)

F, F , pole plates.

K, K , sections of the purlines.

m , ridge tree.

$H H$, and $h h$, common rafters supported at the bottom by the pole plates F, F , in the middle by the purlines, K, K , and at the top by the ridge tree, m .

No. 1, the king post, and tie beam to a larger scale.

No. 2, upper side of the tie beam shewing the mortise.

No. 3, wall plate, shewing how it is made to receive the tie beam.

No. 4, underside of the tie beam.

No. 5, and 6, end of the roof to a larger scale.

Fig. 1.

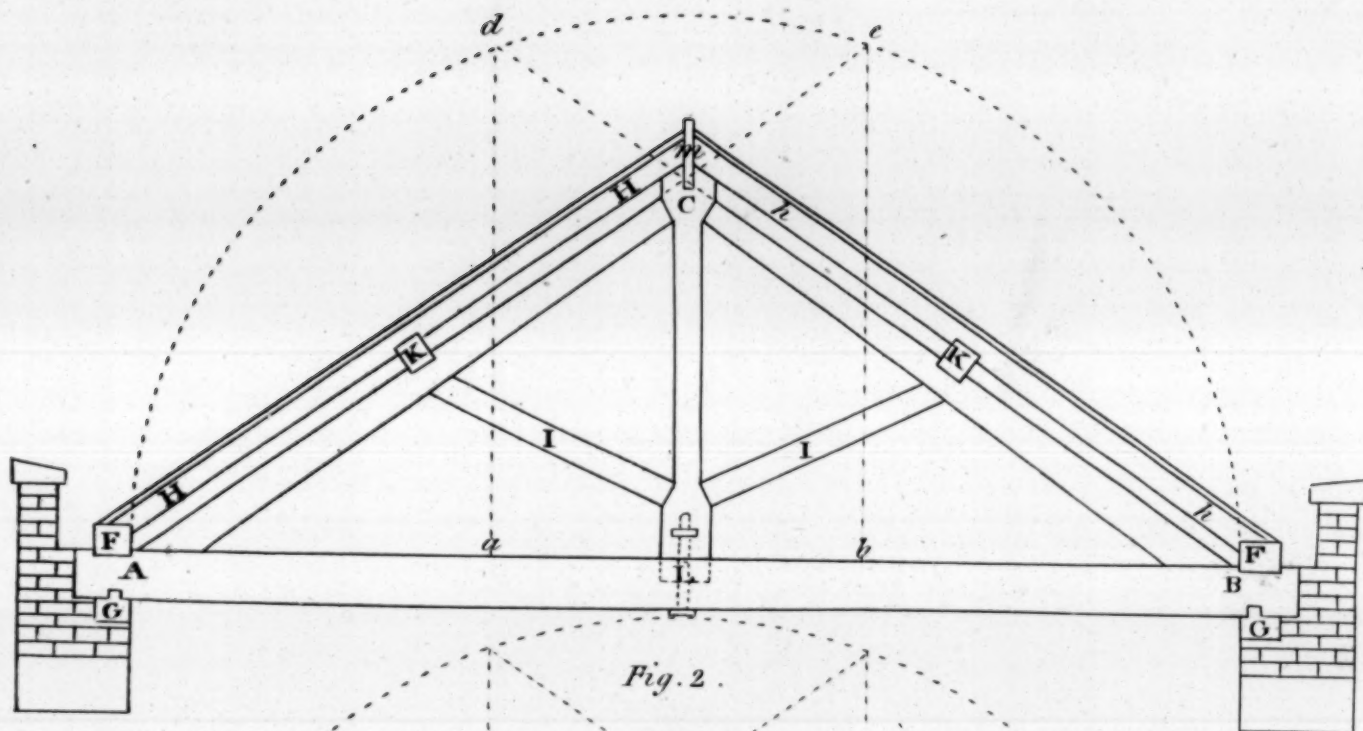
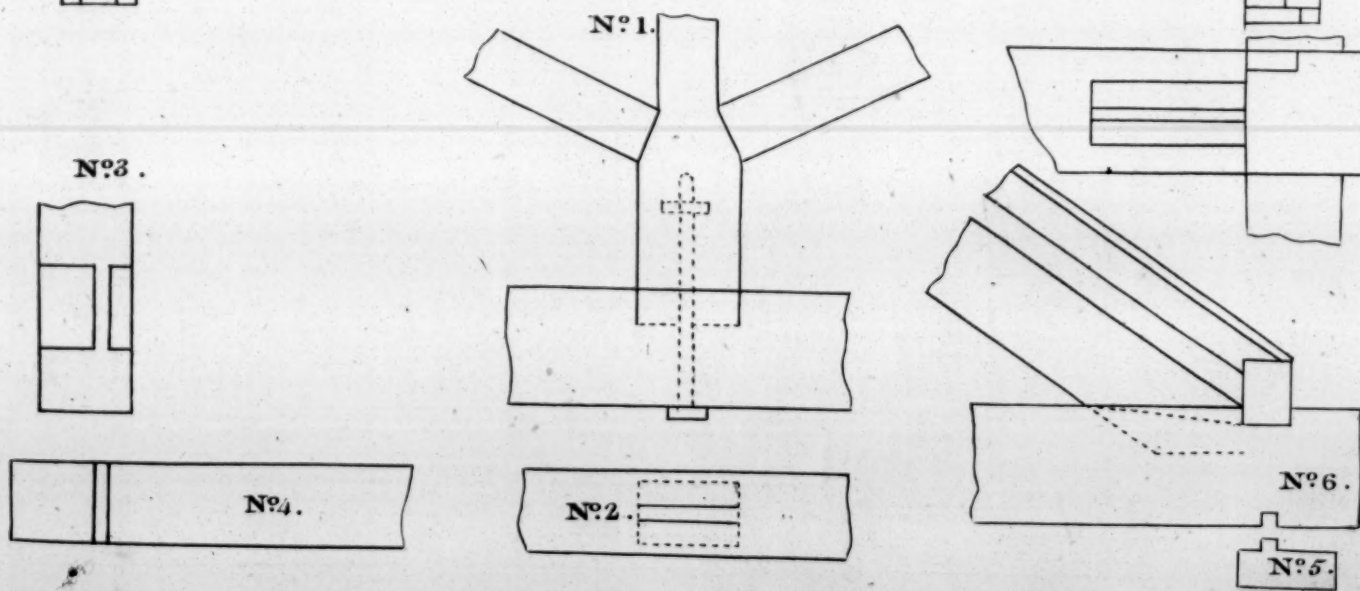
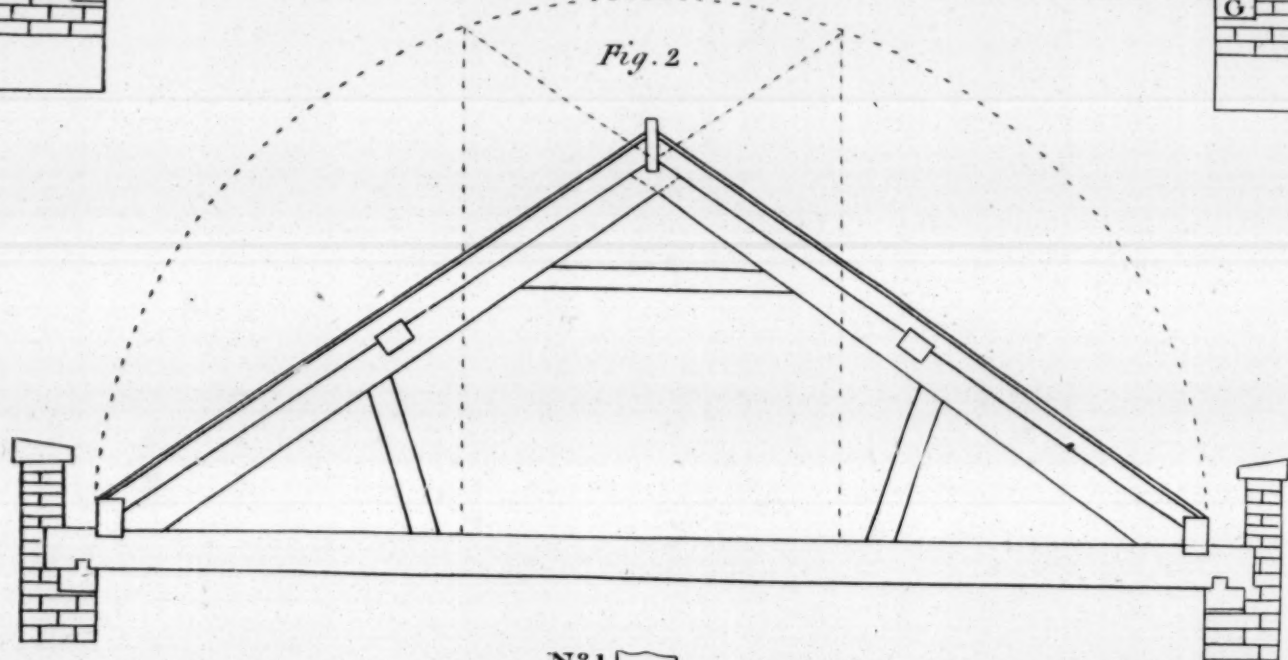
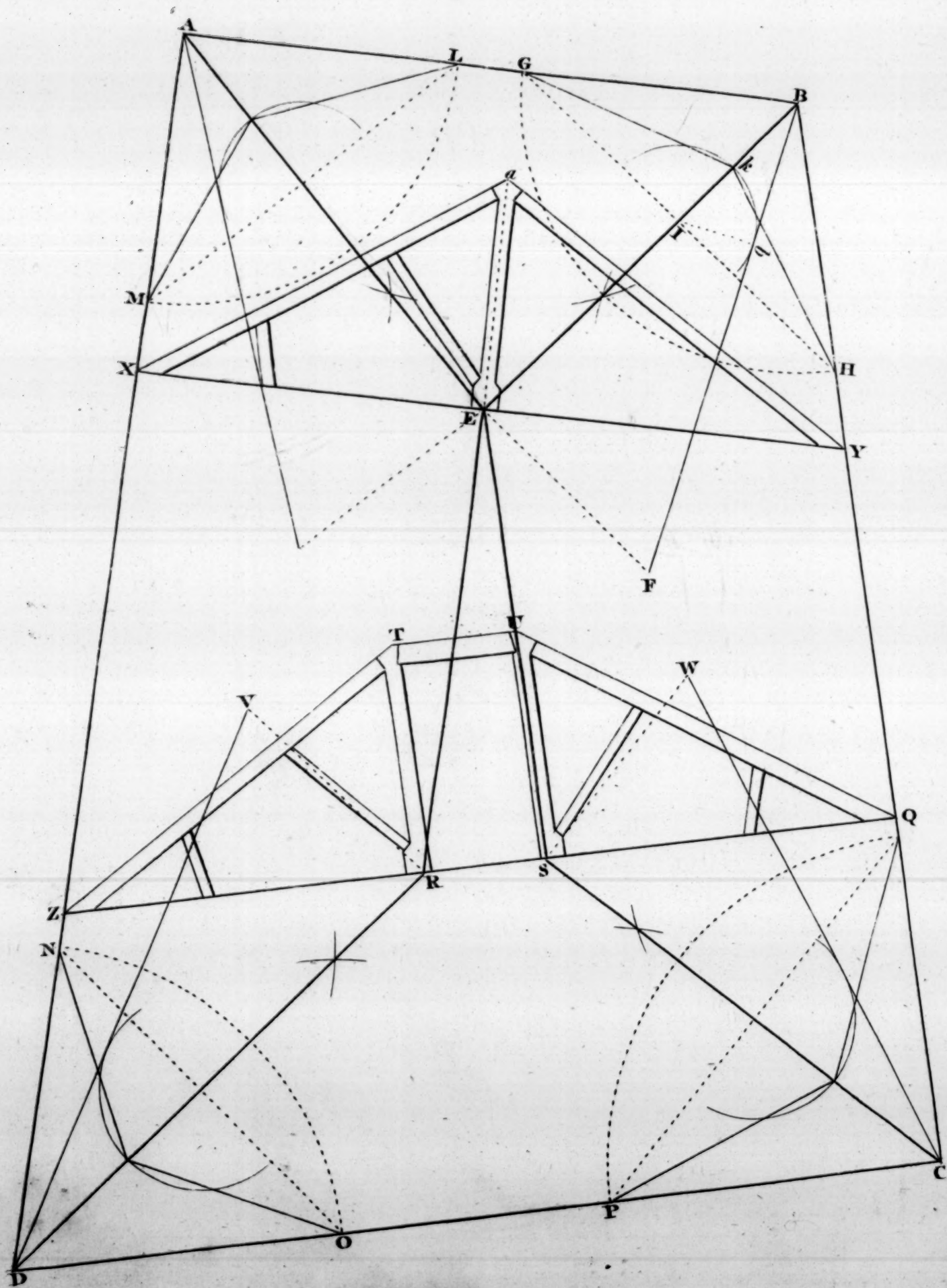


Fig. 2.











Pl. 43.

Fig. 1.

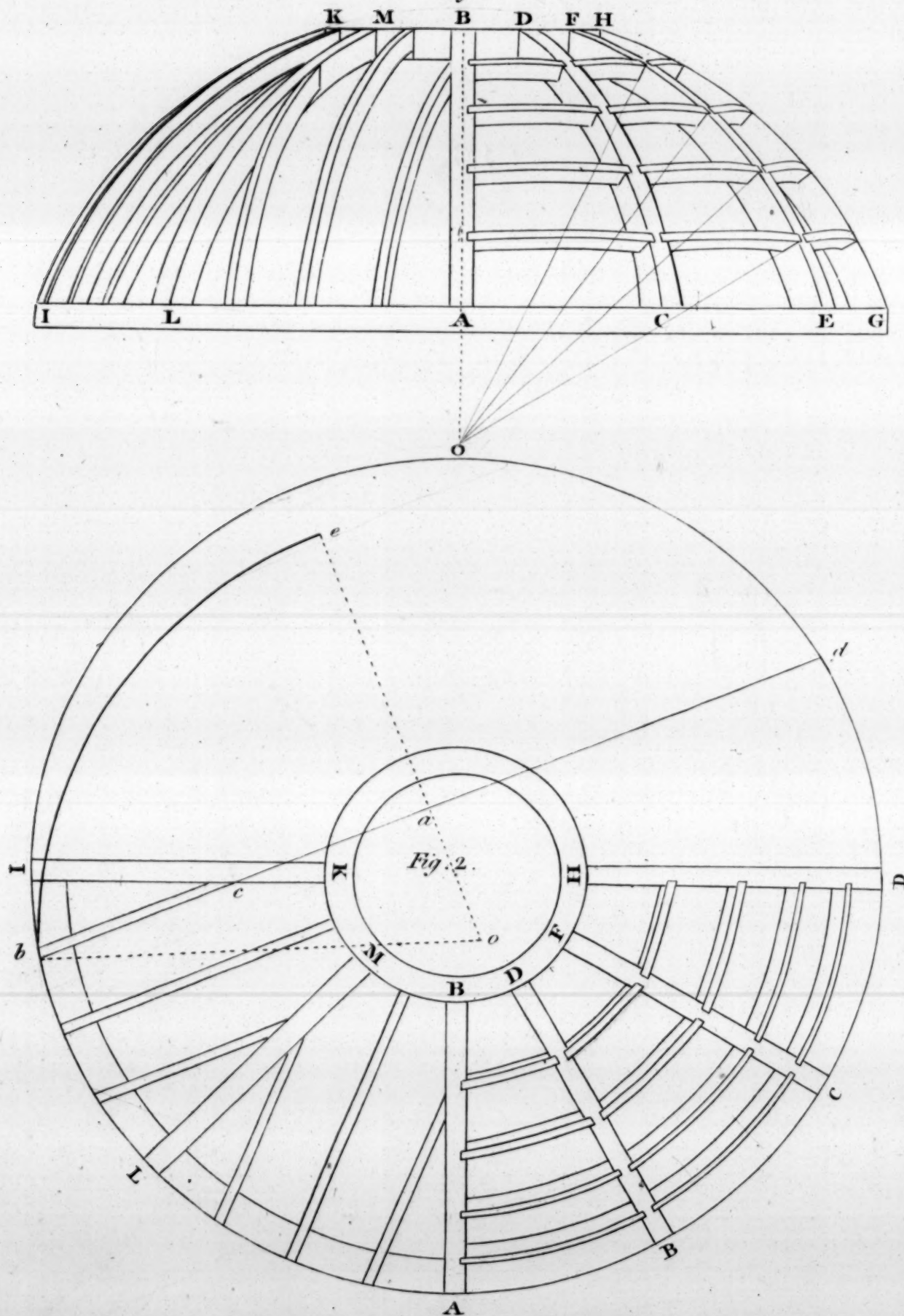


PLATE XII.

ROOFS.

To make a roof when the plan is of the form of a trapezium.

Let $ABCD$ be the plan, bisect all the angles LAM , GBH , QCP and ODN , respectively, by the right lines AE , BE , CS , and DR , which will give the seat, or plan, of the hips. Through E , the intersection of the lines AE and BE , draw XY parallel to AB , cutting the sides of the plan in X , and Y ; from E , draw Ea perpendicular to XY , equal to the intended height of the roof; draw aX and aY , which will give the hip rafters to stand over XY ; also through E , draw ER , and ES , respectively parallel to AD , and BC , the plan of the roof cutting the plan of the hips DR and CS , at R and S , through R and S ; draw $ZRSQ$ cutting AD , and BC , at Z and Q , then will ERS be a flat on the top.

To find the hip rafters.

From E draw EF , perpendicular to BE , equal to Ea ; join BF , and BF will be the length of a hip rafter, to stand over EB , on the plan.

To find the angle at the back of the hip rafters.

Draw any line GH , perpendicular to BE , cutting it at I , and the plan at G and H ; through I , draw Ib , perpendicular to BF , cutting BF in b ; make Ik equal to Ib , join Gk and kH ; then will GkH be the angle sought.

PLATE XIII.

ROOFS.

How to fix and describe the ribs in a dome, when the plan is a circle, and the elevation a segment of a circle.

METHOD I.

Fix the principal ribs, as are shown at AB , CD , EF , and GH , in the elevation and plan, fig. 1 and 2; then cut out small notches in their outer edges, in order to receive the cross bars, which cut the principal ribs at right angles, the sides of each bar being in planes,
C
tending

tending to the centre of the dome: fixing the bars in this manner is extremely easy, as all the cross ribs are of the same curve as the principal ribs; these cross ribs being well fixed, by this method it will be as strong as any trussed dome and much less expensive.

METHOD II.

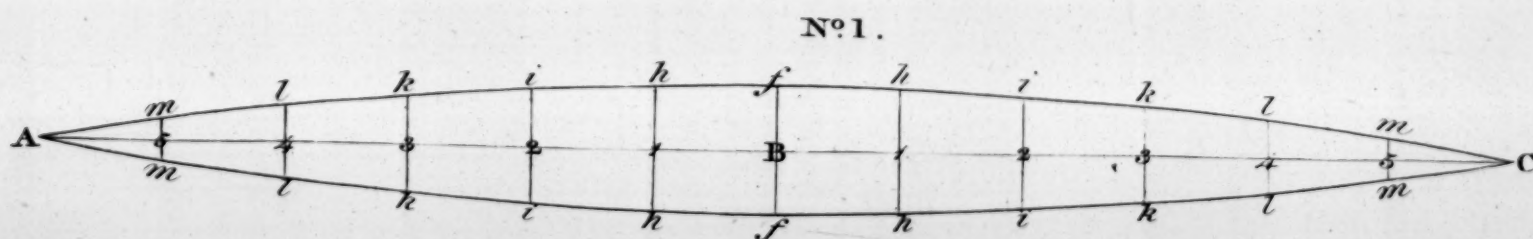
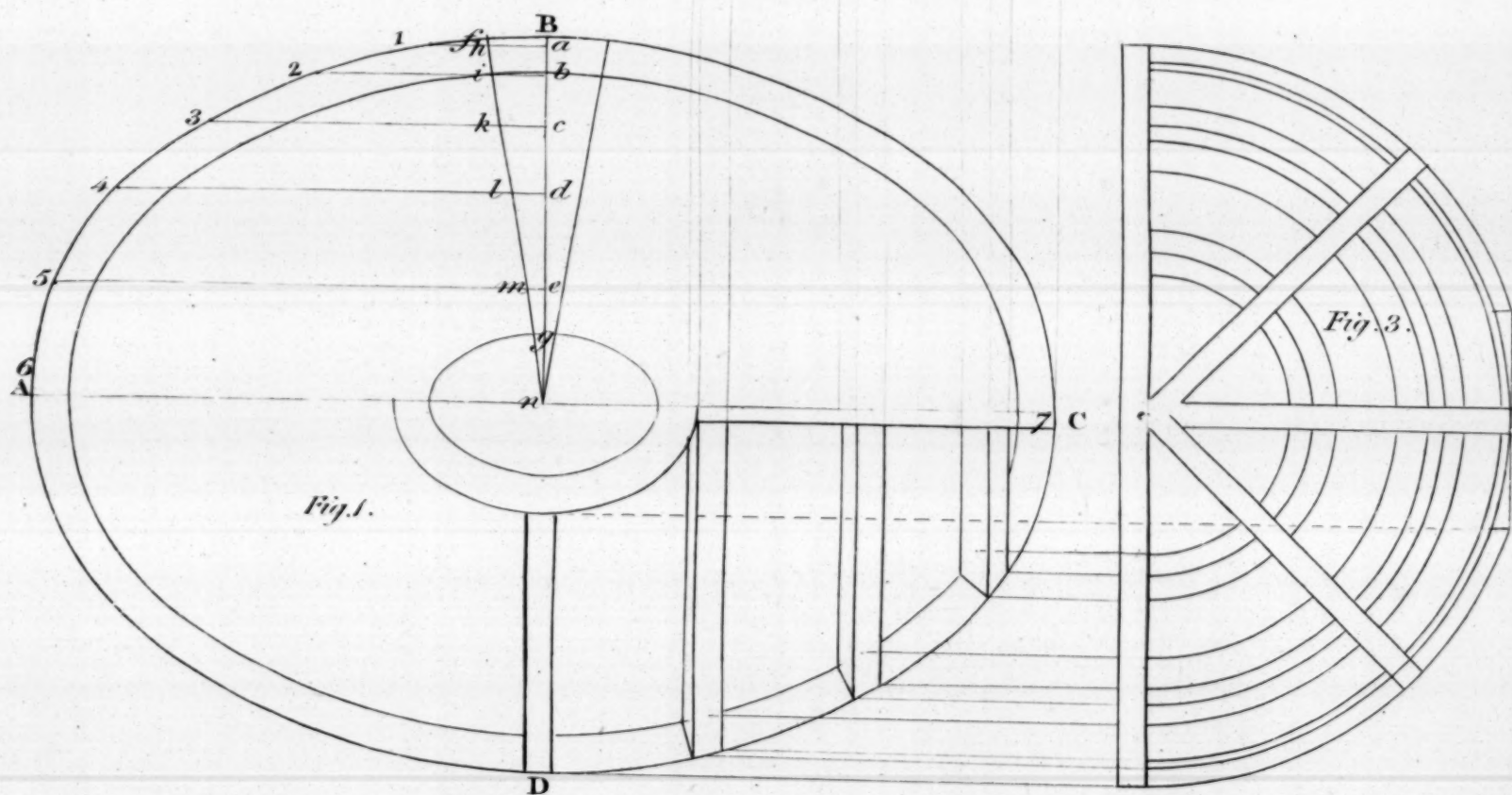
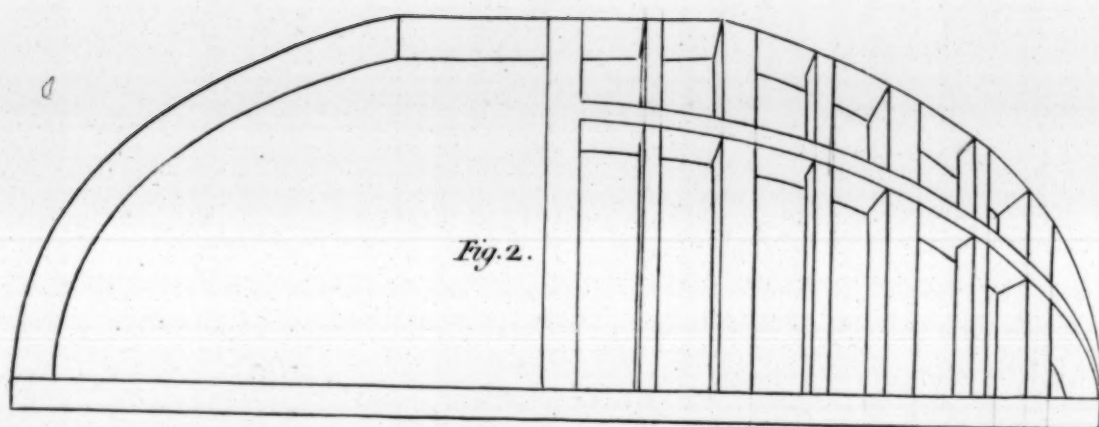
On the other half is shown the principal ribs at IK , LM , and AB , at the elevation, *fig. 1*; and on the plan, at *fig. 2*, the principal ribs are filled in between by parallel jack ribs; the manner of finding the centre of them is as follows: suppose bc , on the plan, to be a jack rib; continue it till it meet the opposite side, at d ; then bisect bd , by a perpendicular oae , at a ; make ao , equal to AO on the elevation; then with a radius ob , describe the arc be ; it will be the curve required.

PLATE XIV.

ROOFS.

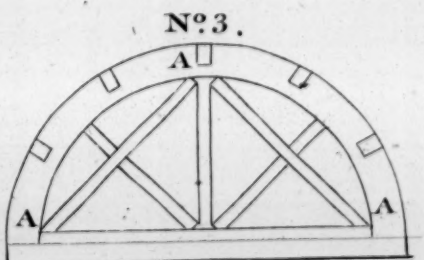
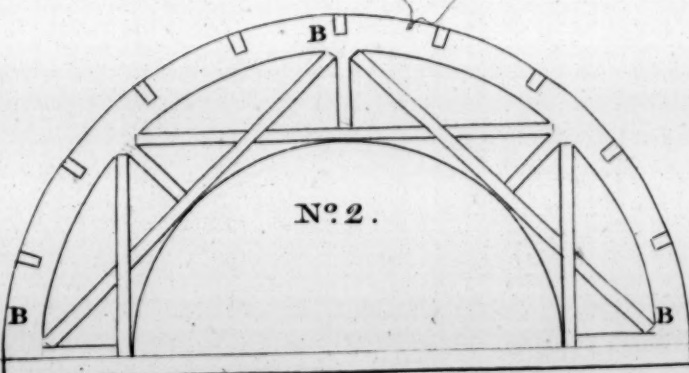
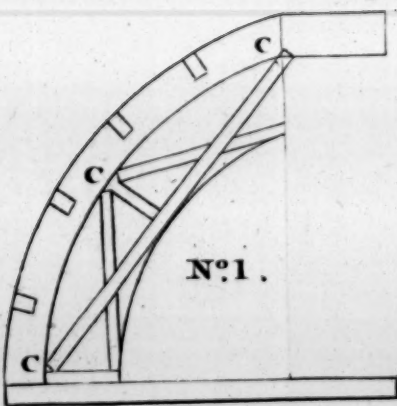
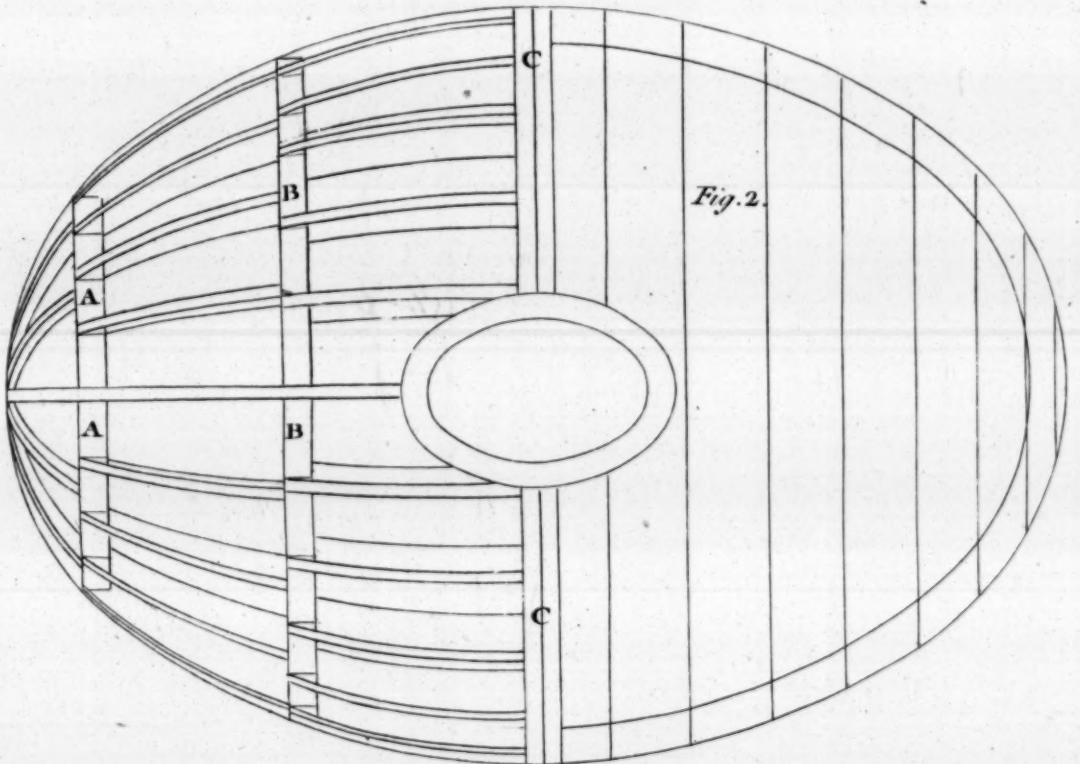
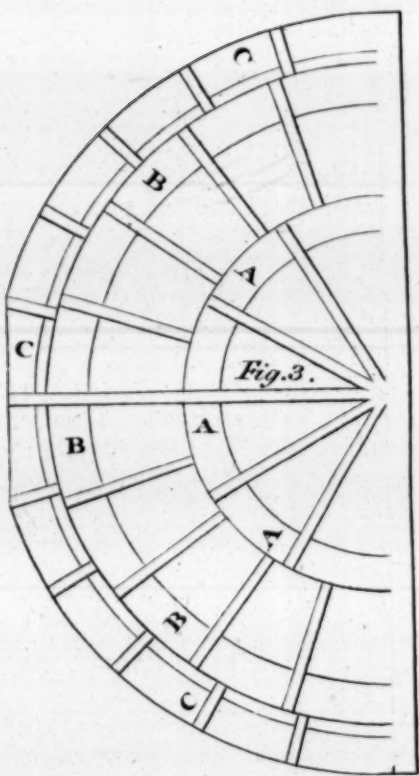
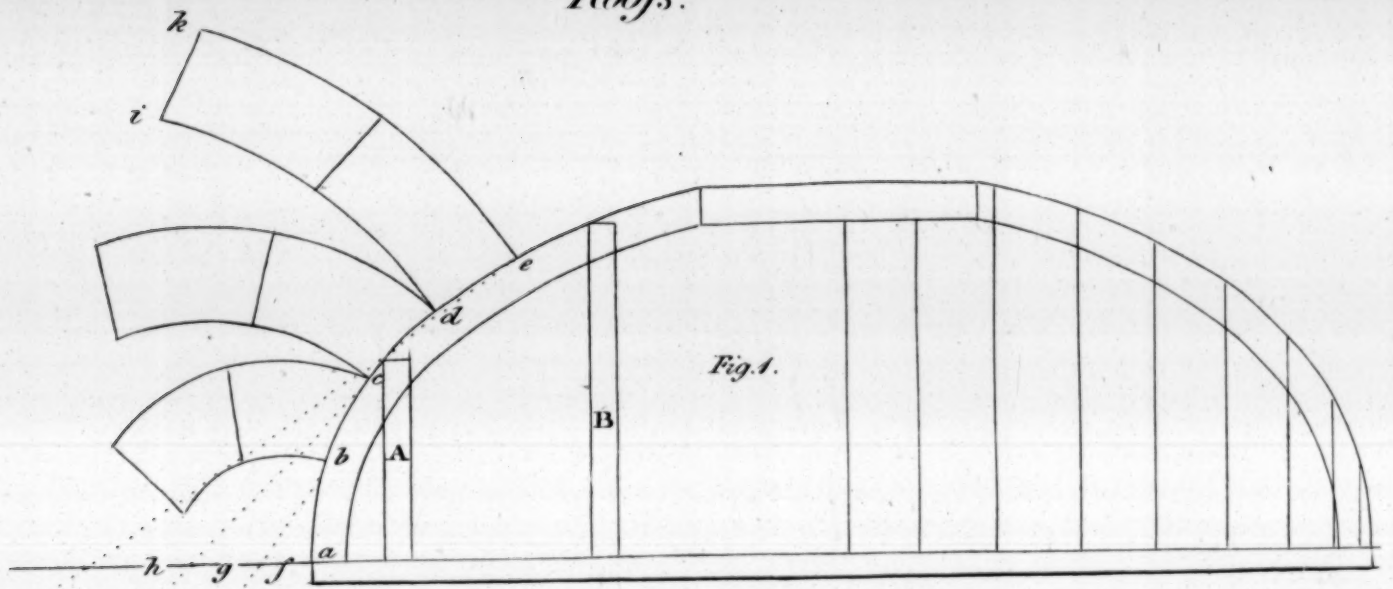
How to cover the whole of a spheroidal dome with one mould only, when the base or plan of this dome is a section, passing through the transverse axis of the spheroid, or any other section parallel to it.

Let $ABCD$ be a plan of the dome, which is a section; through the transverse axis of a spheroid, let BD be the conjugate axis; divide one quarter of the plan BA , into any convenient number of equal parts, as six; from these points draw lines, $1ba$, $2ib$, $3kc$, $4ld$, &c.; parallel to the transverse axis AC , cutting the conjugate BD , at the points a , b , c , d , and e ; from B make $B8$, equal to half of any of the equal distances, as between B and 1 , or between 1 and 2 , &c.; draw f^n to the centre, cutting $1a$, $2b$, $3c$, &c. at the points h , i , k , l , m ; from the point B , in the line AC , at No. 1, stretch out the arc BA , of the quadrant, at *fig. 1*, on the plan, as at 1 , 2 , 3 , 4 , &c. through these points, draw ordinates at right angles to AC ; from the several points 1 , 2 , 3 , 4 , &c. in AC , No. 1, make the several distances $1h$, $2i$, $3k$, &c. equal to their corresponding distances, Bf , ah , bi , ck , &c. on the plan, which will give points through which the curve may be completed. The manner of fixing the ribs of this dome is so similar to plate 15, page 11, that no other description is necessary; other differences are plain by inspecting No. 3.











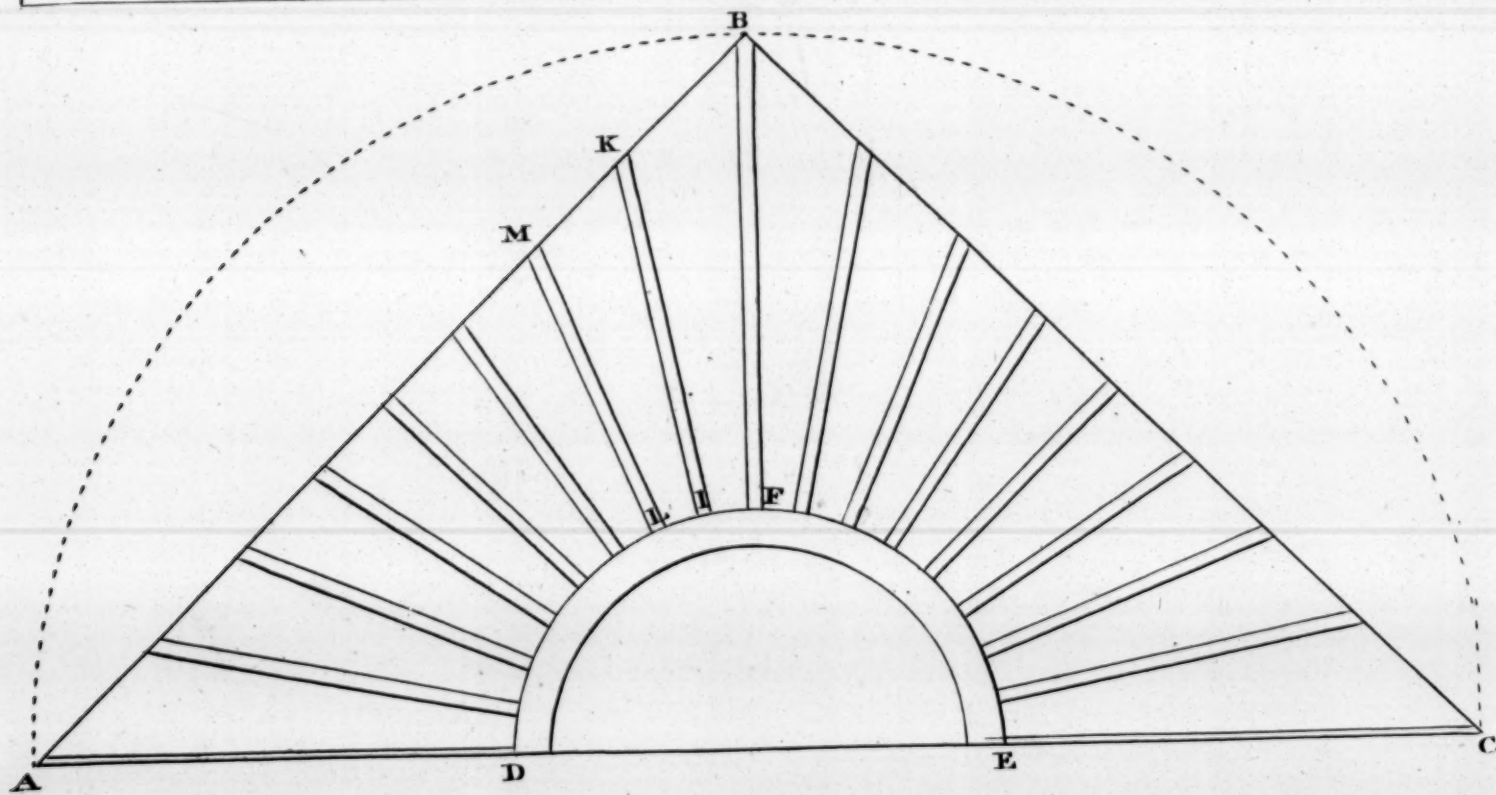
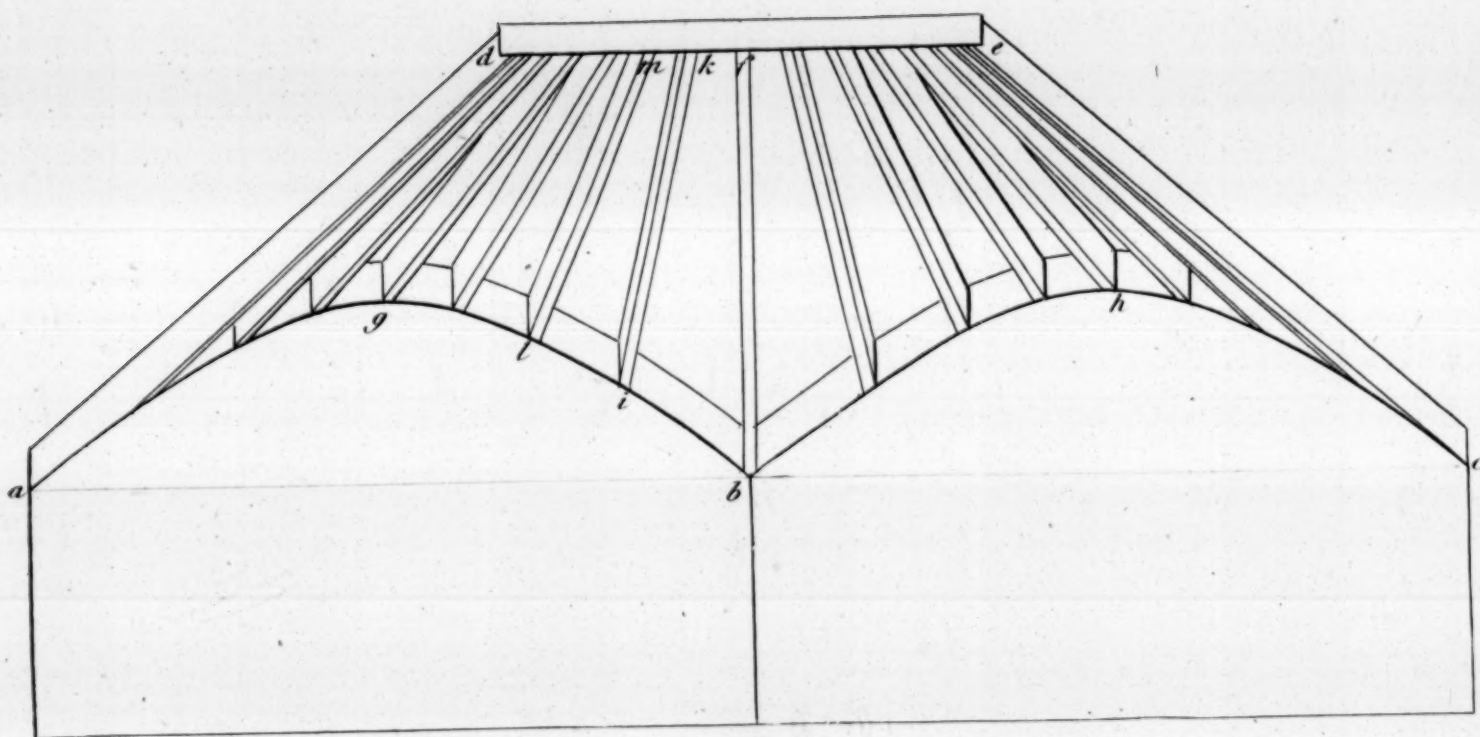


PLATE XV.

ROOFS.

How to cover a spheroidical dome with boards, having all their joists in plains, perpendicular to the tranverse axis of the dome.

FIG. 1, the side elevation, showing the edges of the ribs at *A* and *B*, which are perpendicular to the plan, and parallel to each other.

FIG. 2, the plan, one half showing the plan of the ribs as at *AA*, *BB*, and *CC*.

FIG. 3, the end elevation, which shows the ribs at *AAA*, *BBB*, *CCC*, which are all circular; across these ribs are fixed smaller ribs, of the same curve as the plan, as is shown in the plan and end elevation. No. 1, shows the middle rib *CC*; on the plan fig. 2, No. 2, shows the rib *BB* on the plan, and No. 3, the rib *AA*, on the plan, or *AAA*, on the elevation; each of the principal ribs are notched on the upper edge, in order to receive the cross ribs, as is shewn at No. 1, No. 2, and No. 3.

How to cover the dome.

On the elevation, fig. 1, take any equal parts as at *a*, *b*, *c*, *d*, and according as you think the width of a board will admit; now to find the curve of any board, suppose one to bend across *de*; through the points *e* and *d* draw the straight line *edh* meeting the axis at *h*; then on *b*, as a centre, with a radius *bd* describe a circle, will be one edge of the board, and with a radius *be*, describe a circle, will give the other edge of a board for that place; in the same manner all the other boards will be found.

PLATE XVI.

ROOFS.

How to fix a conical top over a square room.

Let *ABCE* be half the plan of the room, and *DFE* be the half plan of a curb to which the ribs are all fixed at the top; the hyperbolical arches *agb*, *bhc*, on each of the four sides are all of the same height; in order to fix the straight ribs *bf*, *ik*, *lm*, &c. which are also shown on the plan *FB*, *IK*, *LM*, &c. the manner of finding the hyperbolical curves, *agb*, *bhc*, is shown in the next plate.

PLATE XVII.

ROOFS.

How to determine the intersections of a conical finish over any square room, the diameter of the base of the cone being supposed equal to either of the diagonals of the square, as KL or IM .

Bisect the diagonal LK , at the point N , by the perpendicular NW ; make NW equal to the height of the cone; then draw the sides LW , and KW ; bisect the side WK of the square at a ; on the point N , with a radius Na describe an arc aA , cutting the diagonal LK , at A ; then take at pleasure the points B , C , and D , between A and K , and with the several radii NB , NC , and ND , describe arcs Bb , Cc , and Dd , cutting KW at the points d , c and b ; from the points A , B , C , and D , draw AE , BF , CG , and DH perpendicular to the diagonal KL , cutting the side WK , of the cone, at E , F , G , and H ; at the points a , b , c , d , erect perpendiculars ae , bf , cg , and dh , to the side ML ; make each of the distances ae , bf , cg , and dh equal to their corresponding distances, AE , BF , CG , and DH will give the edge of one half of the curve for that side, from which all the other may be traced; the shadowed parts on each of these curves show the foot of the ribs so as to bring it to the curb at the top.

PLATE XVIII.

ROOFS.

How to fix the ribs of a spandrel dome standing over a square plan.

CD , DE , fig. 1. are two sides of the plan; AFB is half the plan of the curb; fig. 2. is the elevation, in which is shewn the manner of fixing the ribs on two sides of the plan; ab the elevation of the curb, corresponding to AEB on the plan; efd , and dge , are ribs placed on each side of the plan, which support the vertical ribs which form the spherical surface; and those vertical ribs support the curb afb ; on afb is placed a sky-light to admit of light to the stairs or room; this spandrel dome is to be finished with plaister and consequently the ribs must be at a near distance to each other at their widest places (about one foot or less from centre to centre).

PLATE

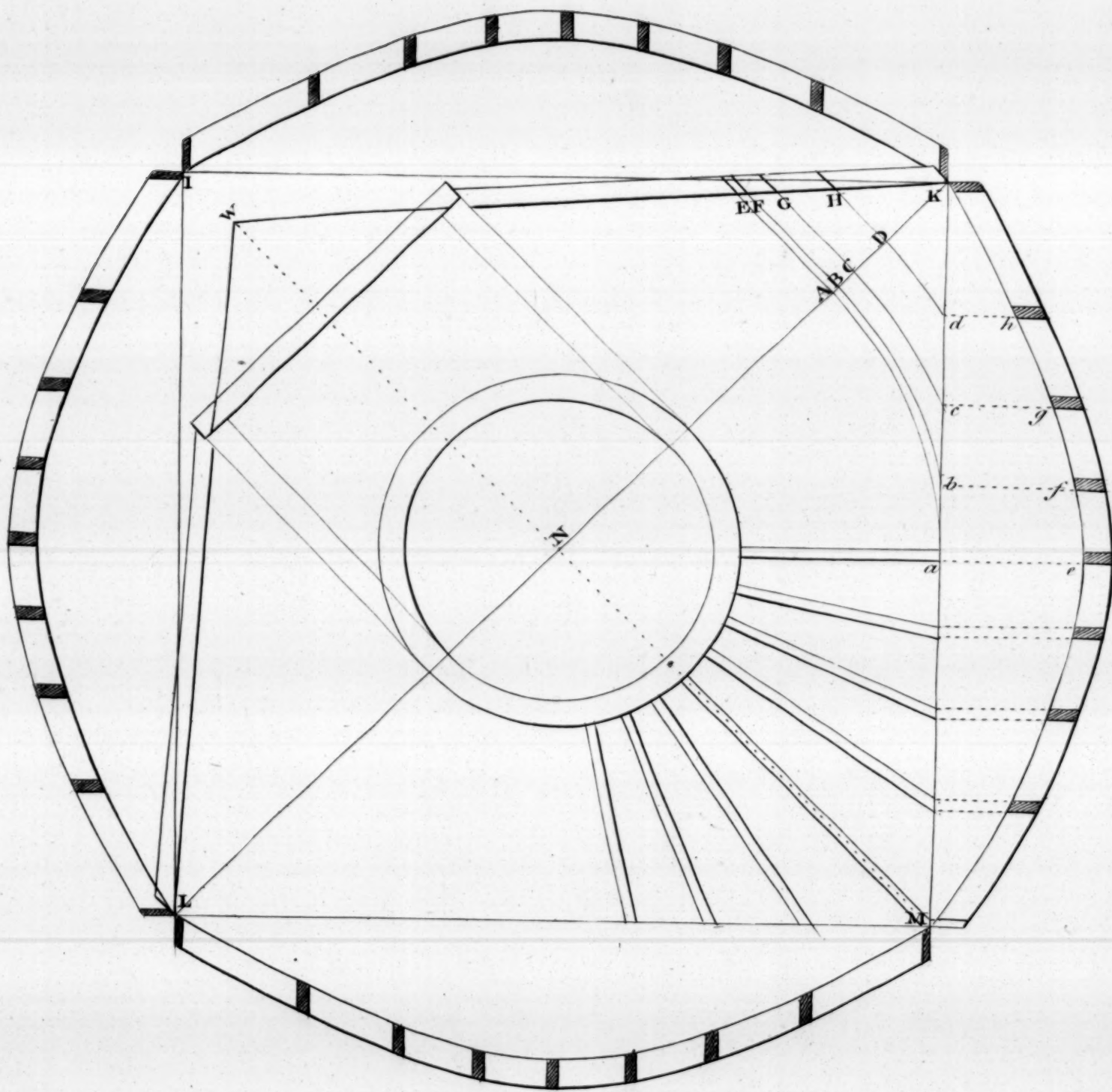




Fig. 2.

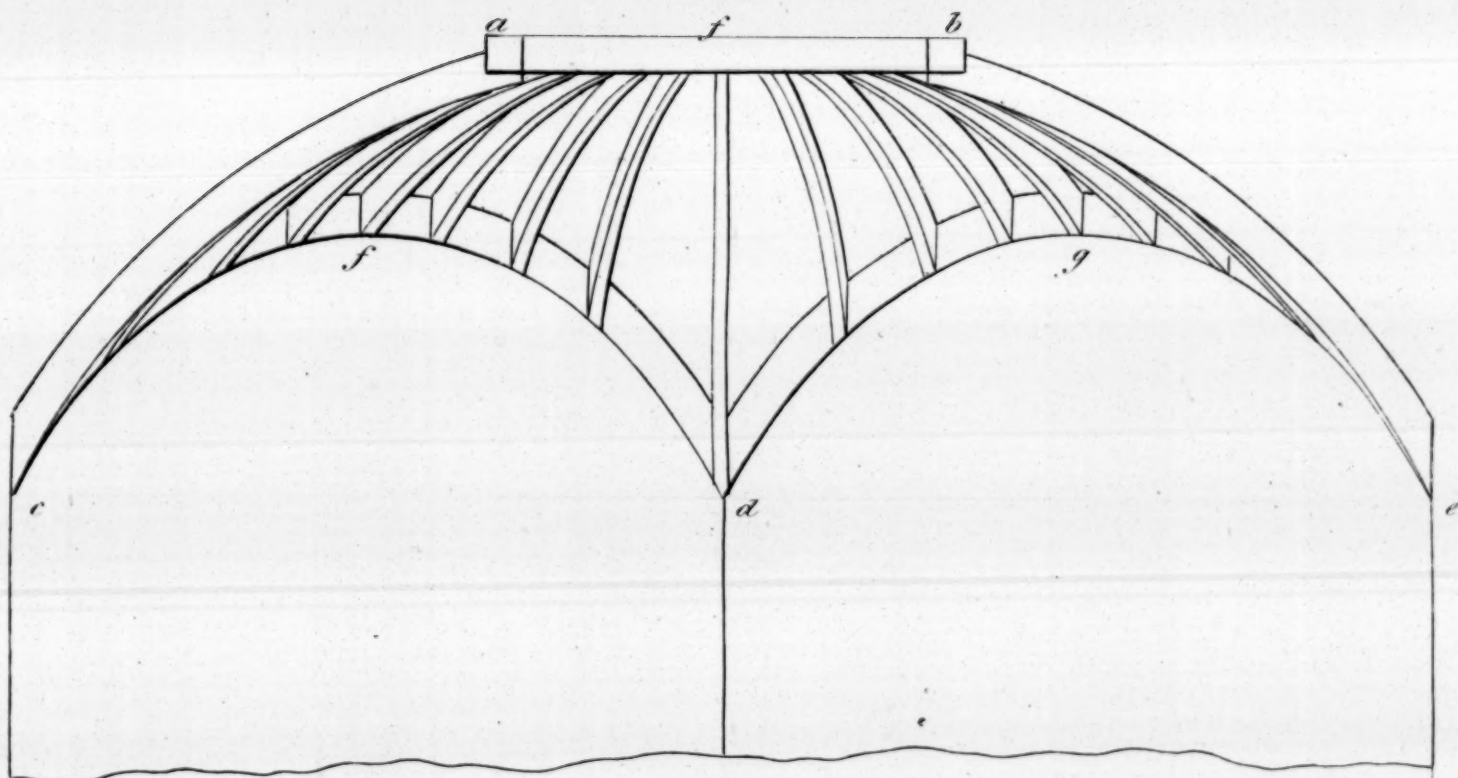
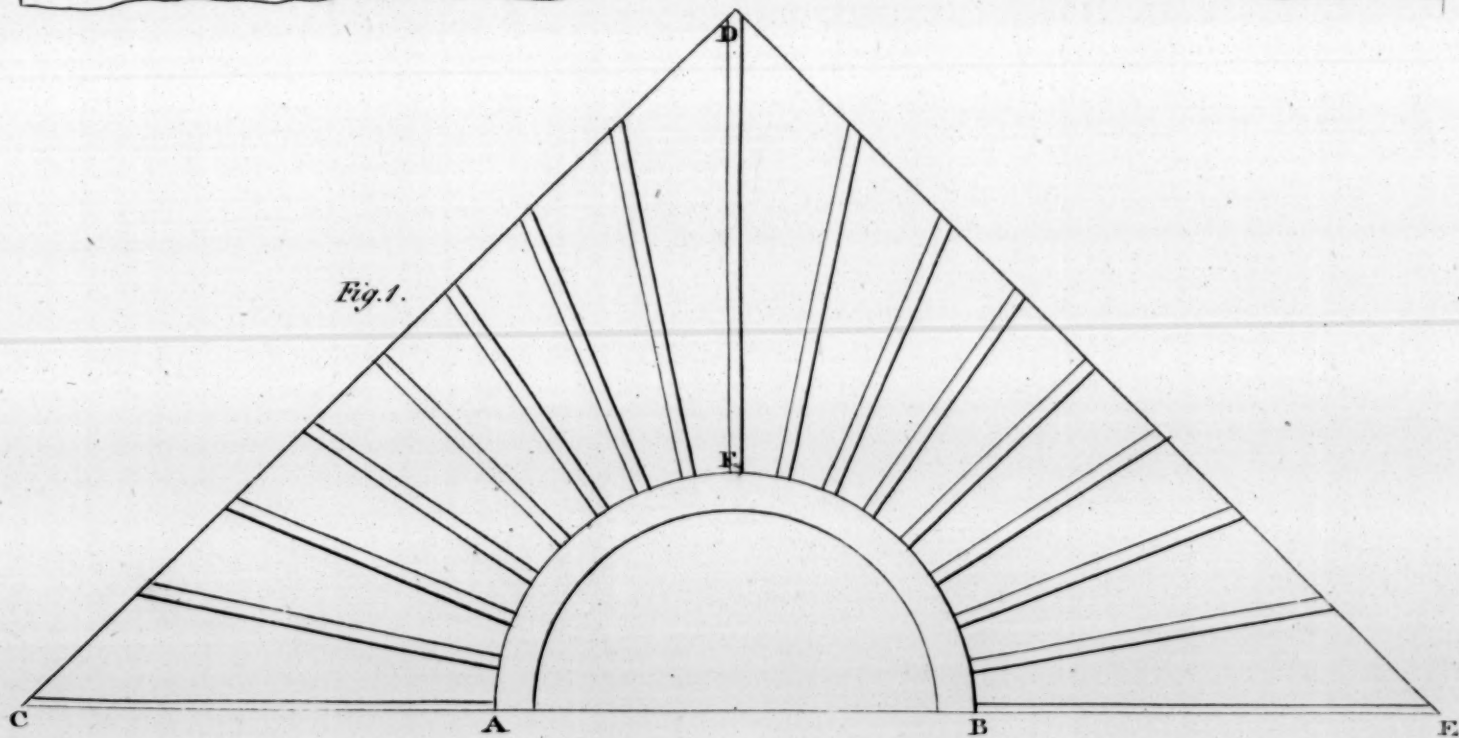
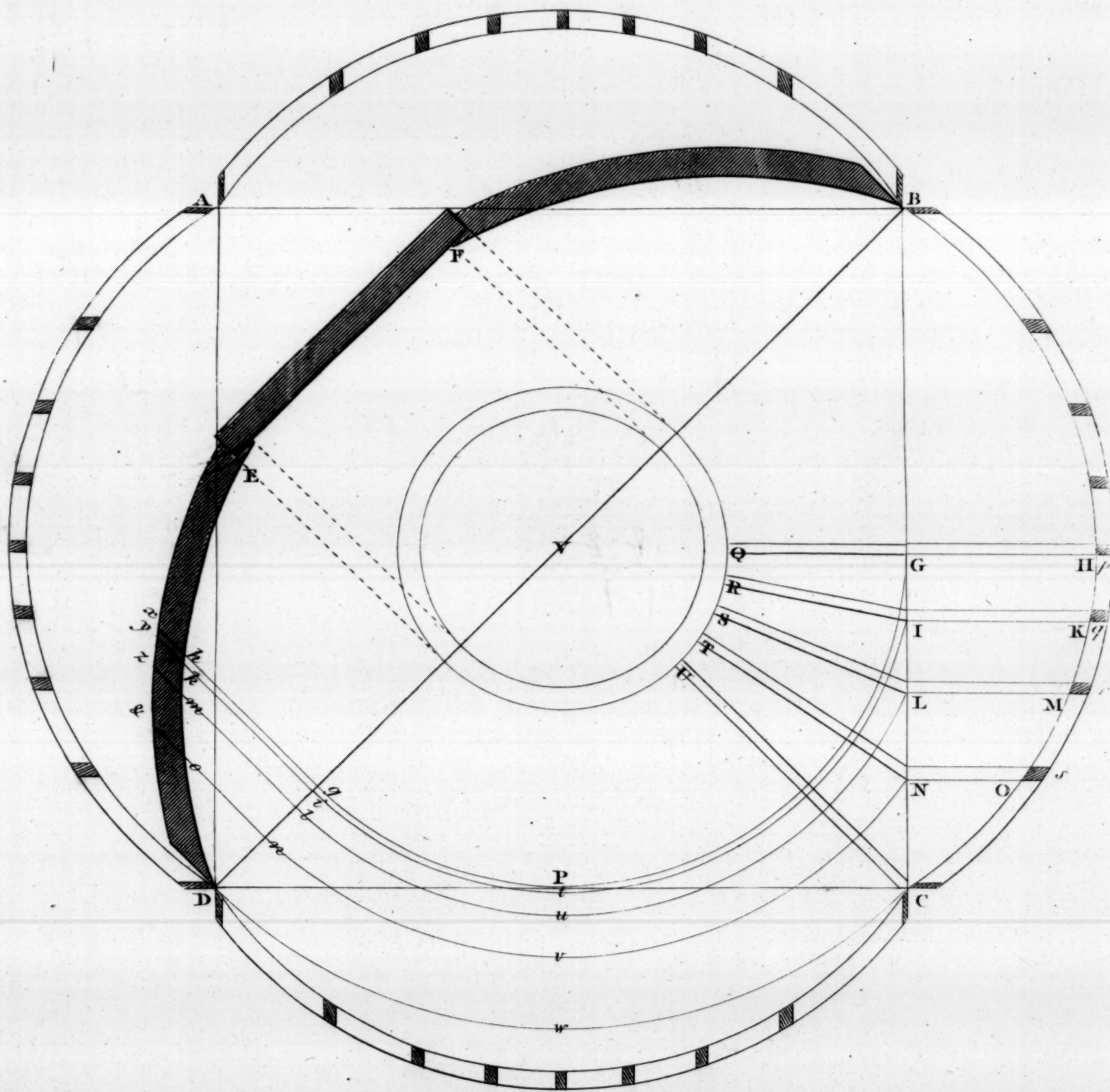


Fig. 1.











Shy Lights.

17.02.

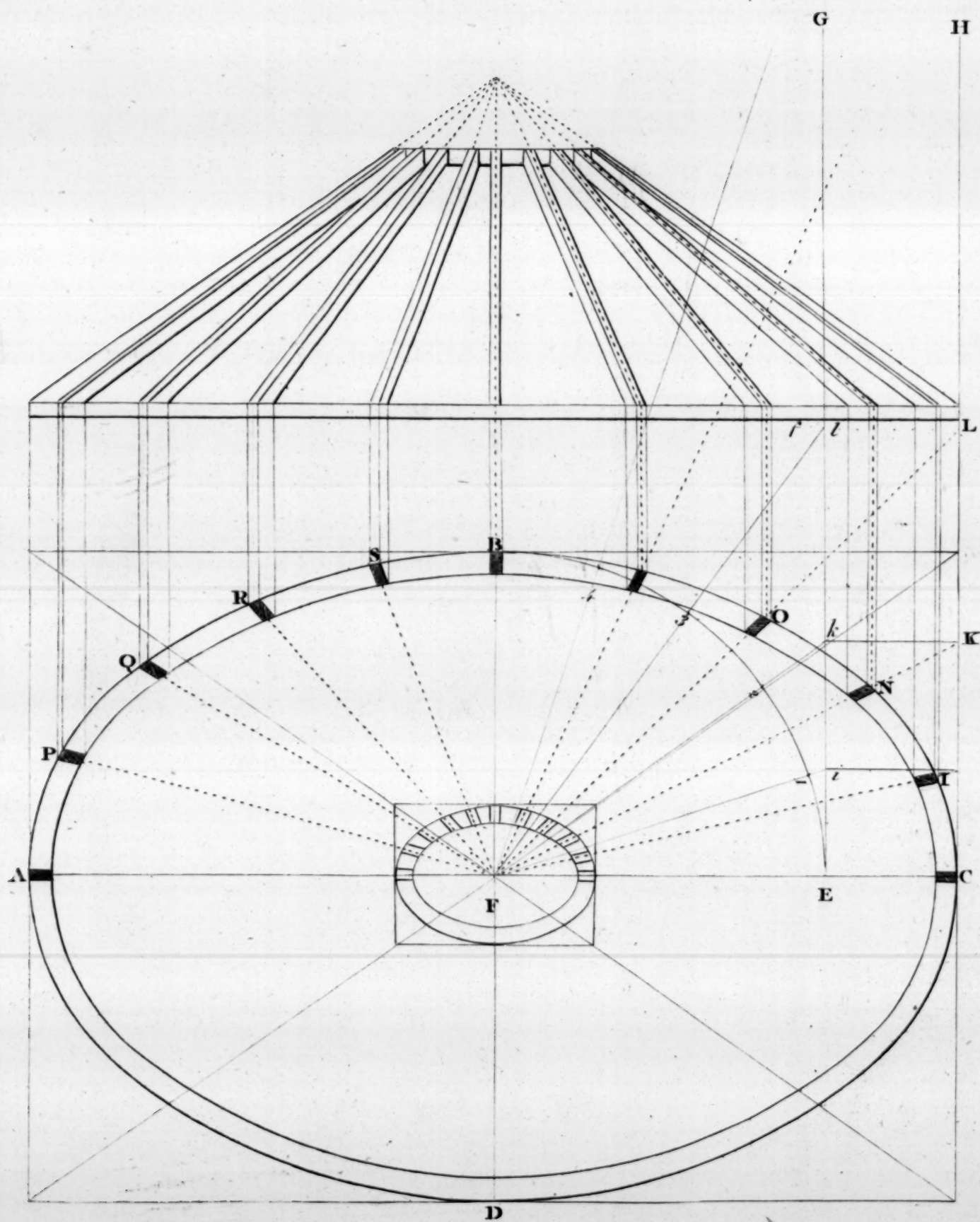


PLATE XIX.

ROOFS.

To find the intersection of the ribs of a spandrel dome, whose section is a given segment of a circle, standing over a square plan, as in plate 17.

Let $ABCD$ be the square plan, and let $DEFB$ be a section of the dome in the plane of the diagonal.

First lay down a plan of one quarter of the ribs, as are shown at UC , TN , SL , RI , and QG , so that QG is parallel to DC or AB , the sides of the square; on V , with the several radii VG , VI , VL , VN , and VC , describe arcs Gpg , Iti , Lul , Nvn , &c. cutting DB the base of the angular rib at g , i , l , and n ; draw gb , ik , lm , and no , each perpendicular to DB , cutting the diagonal rib at b , k , m , and o ; then make all the distances GH , IK , LM , and NO , equal to their corresponding distances gb , ik , lm , and no ; and through the points H , K , M , O , draw a curve and it will give the under edge of the curve for the bottom of the ribs QG , RI , SL , TN , and UC , which is also shown complete on each side of the square plan: now suppose each of the circular segments as are shown on each side of the square plan to be turned up at right angles to the plan $ABCD$, the ribs will then stand in their true position.

PLATE XX.

SKY-LIGHTS.

How to place the ribs of a conical sky-light, so that their distances shall be proportional to the degree of curvature of the plan when it is elliptical.

Let $ABCD$ be the plan, whose centre is F ; let AC be the transverse axis and BD the conjugate; on F , with the semi-conjugate describe the quadrant BE cutting the conjugate at B and the transverse in E ; divide the quadrant BE into as many equal parts as you intend to have ribs in each quadrant: in this example it is in five at the points 1, 2, 3, 4; from the points E and C , draw the lines EG and CH , parallel to BD the conjugate axis; from the centre F , and through the points 1, 2, 3, 4, draw lines $F1i$, $F2k$, &c. cutting EG at i , k , l , &c.; through the points i , k , l , draw iI , kK , lL , &c. parallel to AC , the transverse axis, cutting CH at I , K , L , &c.; from these points draw lines

lines to the centre at F , cutting the circumference of the plan at I, N, O , &c. for the place of the ribs.

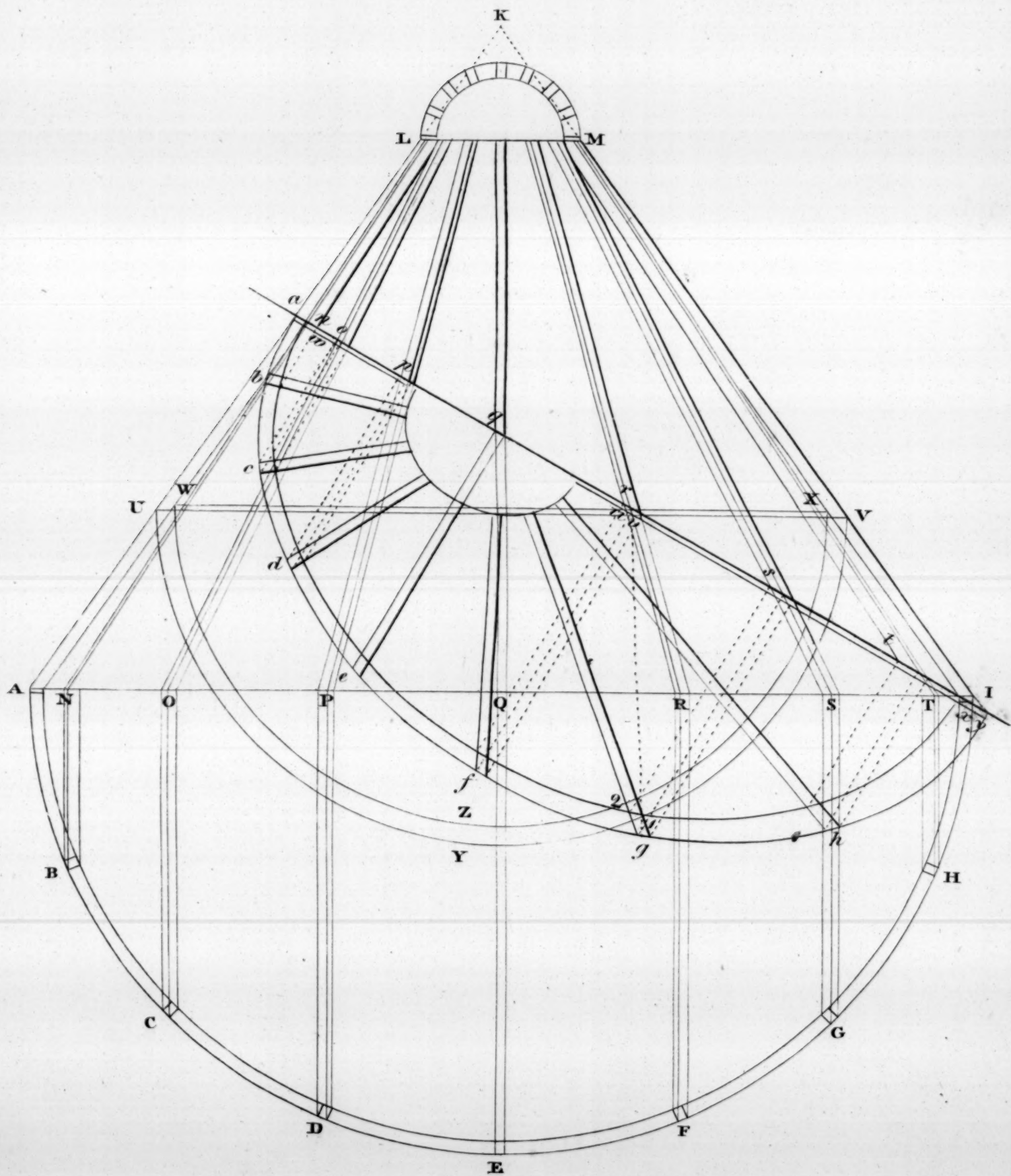
On the other side of the plan the ribs are divided equally at P, Q, R , and S , where it will appear that the spaces towards the transverse axis AP, PQ appear too great for those at the extremity of the conjugate, viz. BS, SR .

PLATE XXI.

SKY-LIGHTS.

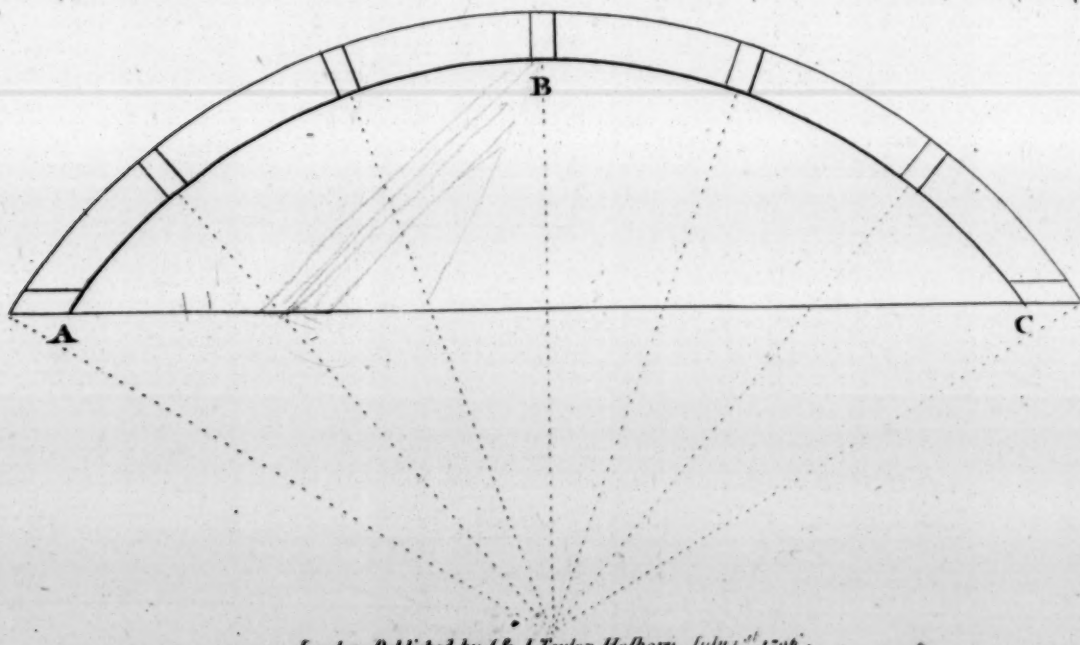
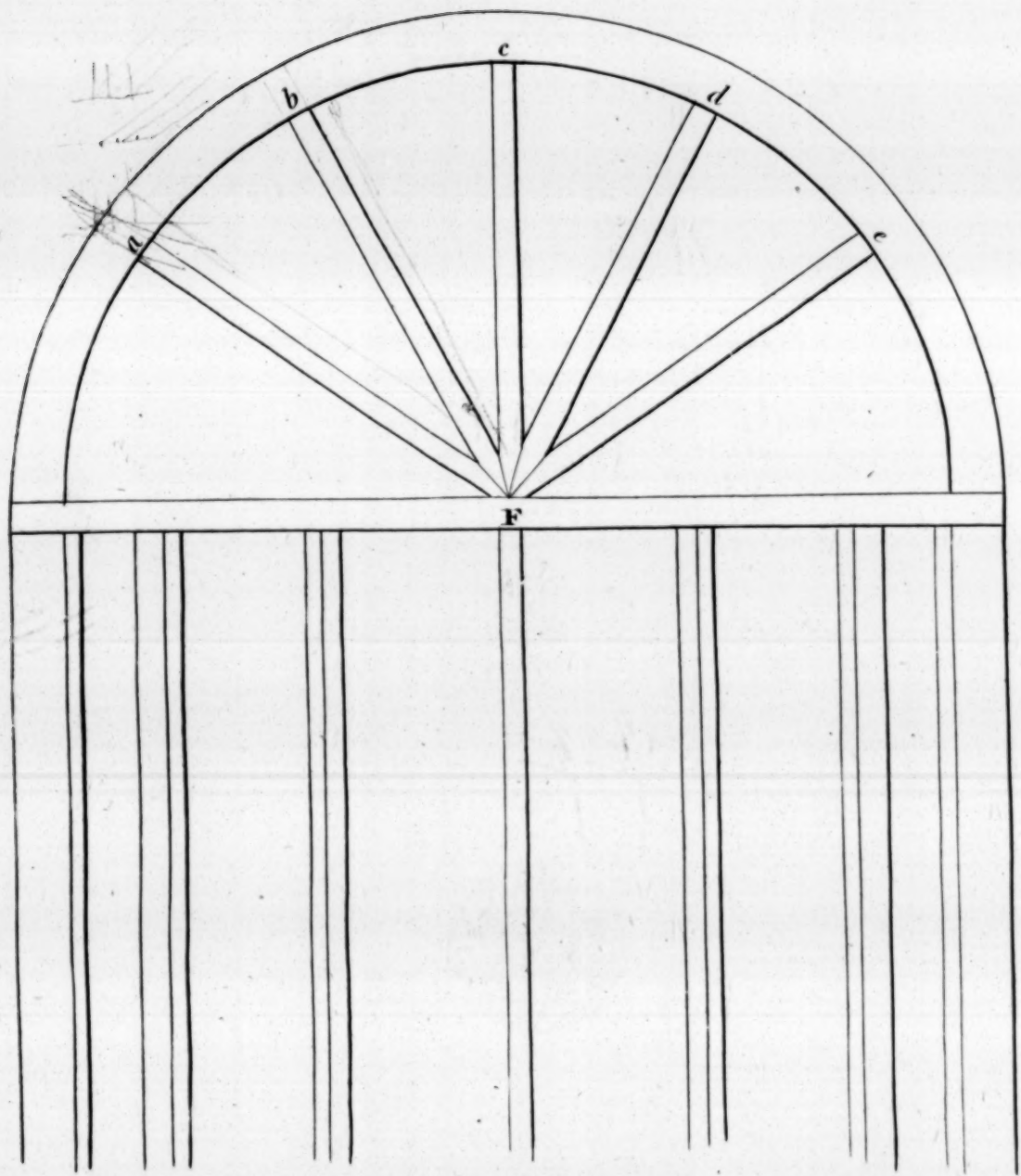
How to draw the curb of a conical sky-light placed on the inclined side of a roof, the base of the cone being a circle, parallel to the horizon, and the axis of the cone perpendicular to its base.

Let ay be the inclined side of the roof, and let the vertex of the cone be at K , and let KQ be the axis of the cone; draw KI and KA making equal angles with KQ , cutting the inclined side of the roof at a and y ; draw any line AI perpendicular to the axis KQ of the cone, cutting the sides KA and KI of the cone at A and I , and the axis KQ at Q ; then on Q with the radius QA on QI , describe a semicircle $ABCDEFGHI$, on which place the plan of the ribs at $ABCD$, &c. from each plan at B, C, D, E , &c. draw lines from their angular points, each perpendicular to AI , cutting AI near N, O, P, Q , &c. from N, O, P, Q , &c. draw lines to the vertex at K , cutting ay at n, o, p, q, r, s, t ; bisect ay at V , through v draw UV parallel to AI , cutting the sides of the cone at U and V ; on UV describe a semicircle UVI ; from v draw vi , perpendicular to UV , cutting the semicircle at i ; make vf from v perpendicular to ay equal to vi ; then will ay be the transverse axis of an ellipsis, and vf will be the conjugate, round which describe the semi-ellipsis $abcdefgh$, which will give one half of the curve for the curb; in the same manner you may proceed with the inside of the curb, which has wx for the transverse axis; then by drawing perpendiculars to ay , from n, o, p, q, r , &c. cutting the curb at $bcdefgh$, will give the places of the ribs, and by drawing them to q will give their several directions.











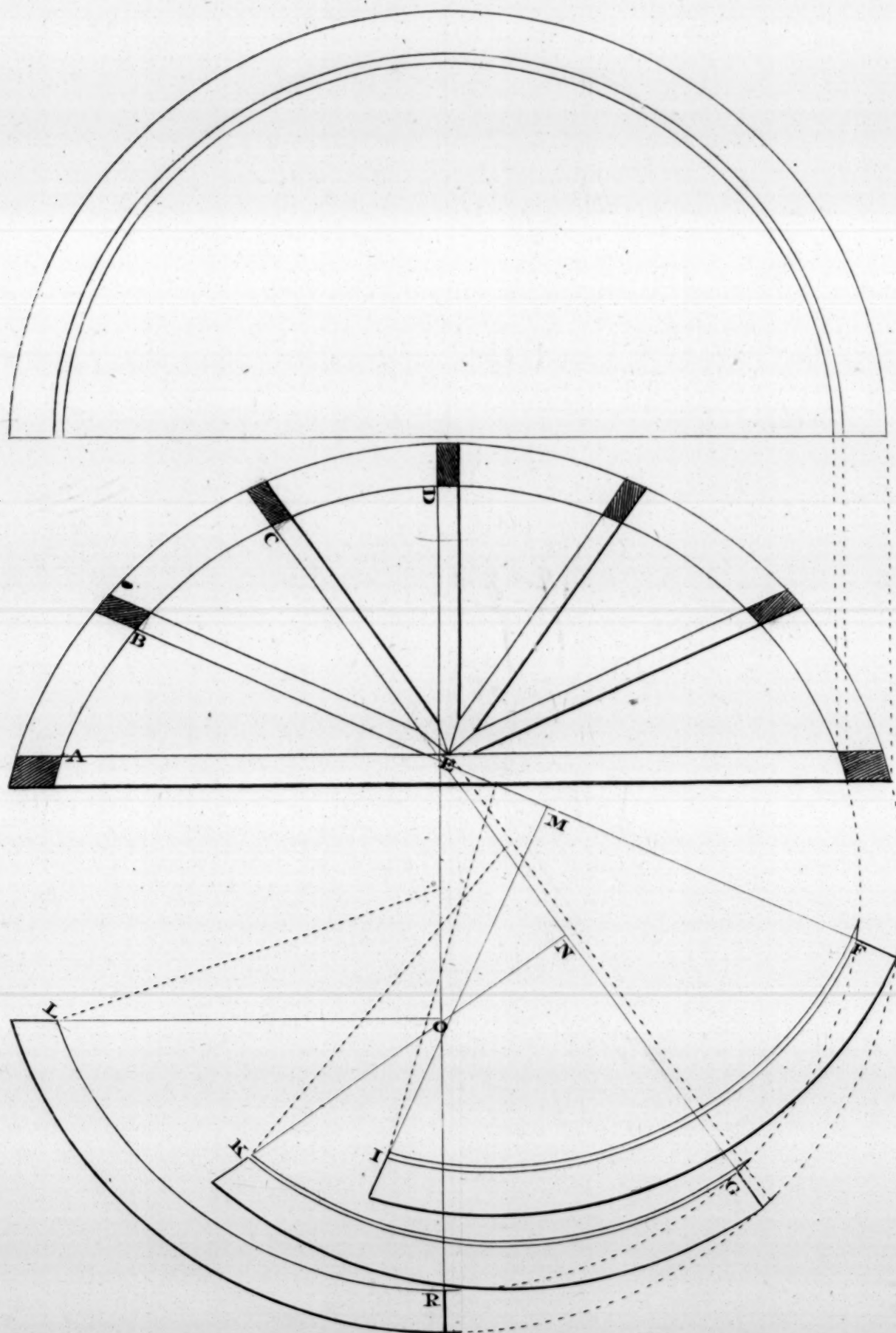


PLATE XXII.

NICHES.

How to draw the ribs for the top of a niche, the head being a semicircle and the plan a segment.

Let ABC be the plan of the niche, then one half, as AB or BC , will give any one of the ribs which are to be fixed upon the front rib at a, b, c, d, e , equally spaced, and to mitre together upon the back at F .

PLATE XXIII.

NICHES.

To find the ribs of a spherical niche which is the segment of a circle on the plan, and a semicircle on the elevation, the ribs not to tend to the centre of the sphere, but to a point in the back of the front rib of the niche.

Let AE, BE, CE , and DE be the plan of half of the ribs; now, in order to find a rib standing over any of these plans, suppose over BE , produce it out to F , cutting the circumference of the plan at F make FM equal to BE on BF , as a diameter; describe a part of a circle FI from M ; draw MI perpendicular to MF , cutting the arc at I , then will the arc FI be the under edge of the rib, standing over EB ; the breadth of the ribs may be what is thought proper: all the other ribs are described in the same way by producing their plan to the opposite side of the circumference.

Note. Be careful that each rib be backed to the plan, as is shewn in the ribs FI, GK , and RI .

PLATE

PLATE XXIV.

NICHES.

How to describe the ribs of a niche when parallel to each other, whose top is part of a globe, the plan being the segment of a circle and the elevation a semicircle.

Draw the plan and elevation of the ribs; from the centre C of the plan, and with the radius CL draw the inside circle of the plan all round, produce the ribs till they meet the opposite side of the plan at I , FG , CD ; through C the centre of the plan draw MCN , parallel to KRL , the face of the niche, which will cut the plan of the ribs produced at A and B , on the points CA and B , as centres; with the radii CI , AF , and BC , respectively describe arcs IW , FV , and CT ; and from the points G and D draw the lines GH and DE , perpendicular to the plan of the ribs, cutting the base of them at H and E ; then again, on the centres A and B , with the radii AH and BE respectively, describe arcs HU and ES ; then will IW be the inside of the rib at No. 1. and FV , and HU , the inside and backing of the arch No. 2; likewise CT and ES , the inside and backing of No. 3; the outside lines, representing the width of these arches, must be taken according to the discretion of the workman.

Note.—The ribs No. 1, 2, and 3, correspond to the plans marked 1, 2, and 3.

PLATE XXV.

NICHES.

How to draw and fix the ribs of a circular niche in a circular wall, by an easy practicable method.

Let $abcd$ be a plan of the inside of the wall $ABCD$, the inside of the ribs of the niche which are all drawn towards the centre at E , that is the middle of the plan of each rib, will pass through E the centre of the niche; take either of the distances EA , EB , EC , &c. and with that distance take any points H , G , and F , at No. 1, No. 2, No. 3, as centres, and describe arcs BIK , CLM , and DN , which will be the inside of each rib; draw the radius of each, that is BH , CG , and DF .

How

Fig. 1.

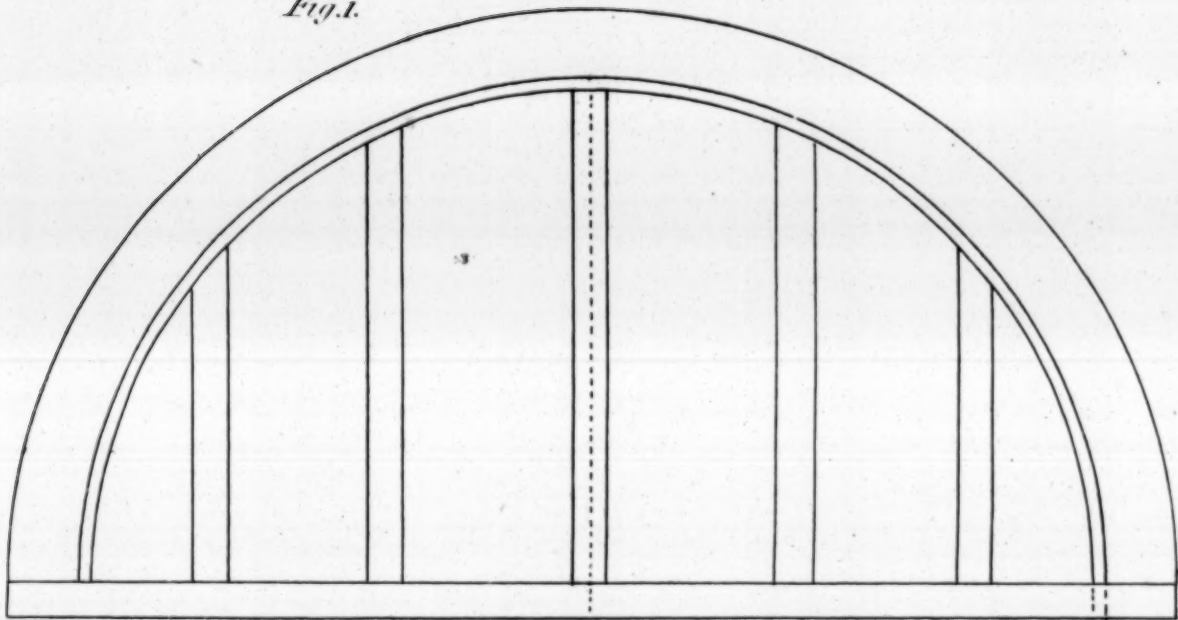
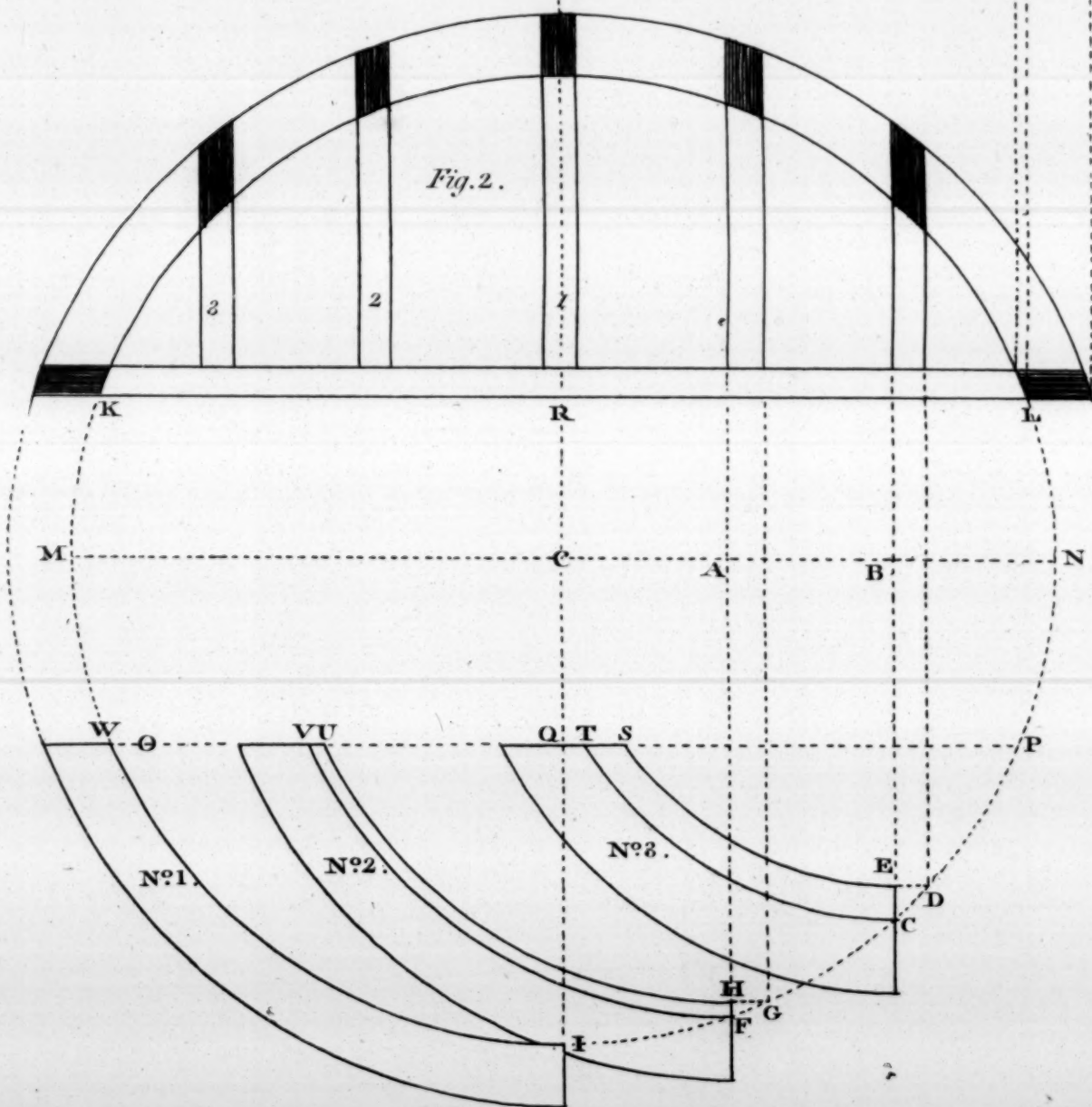
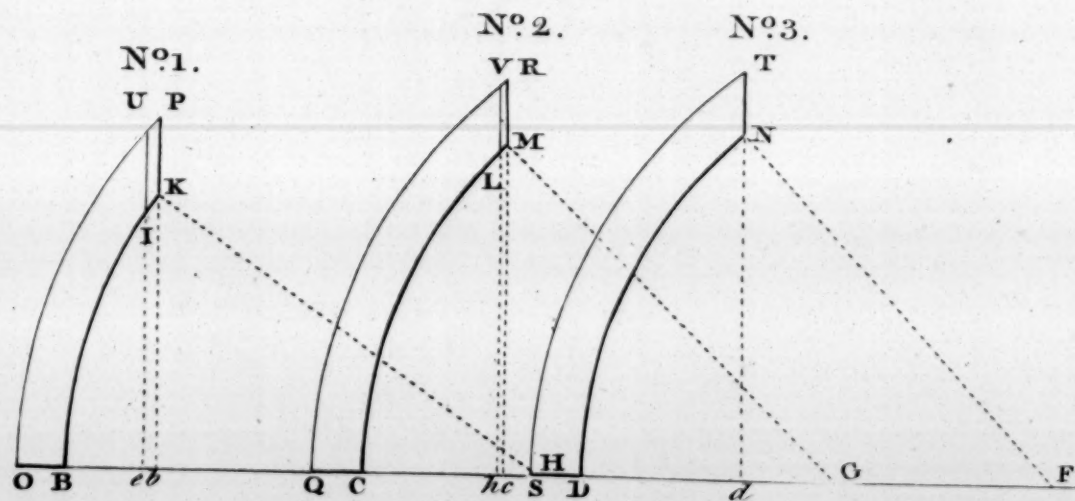
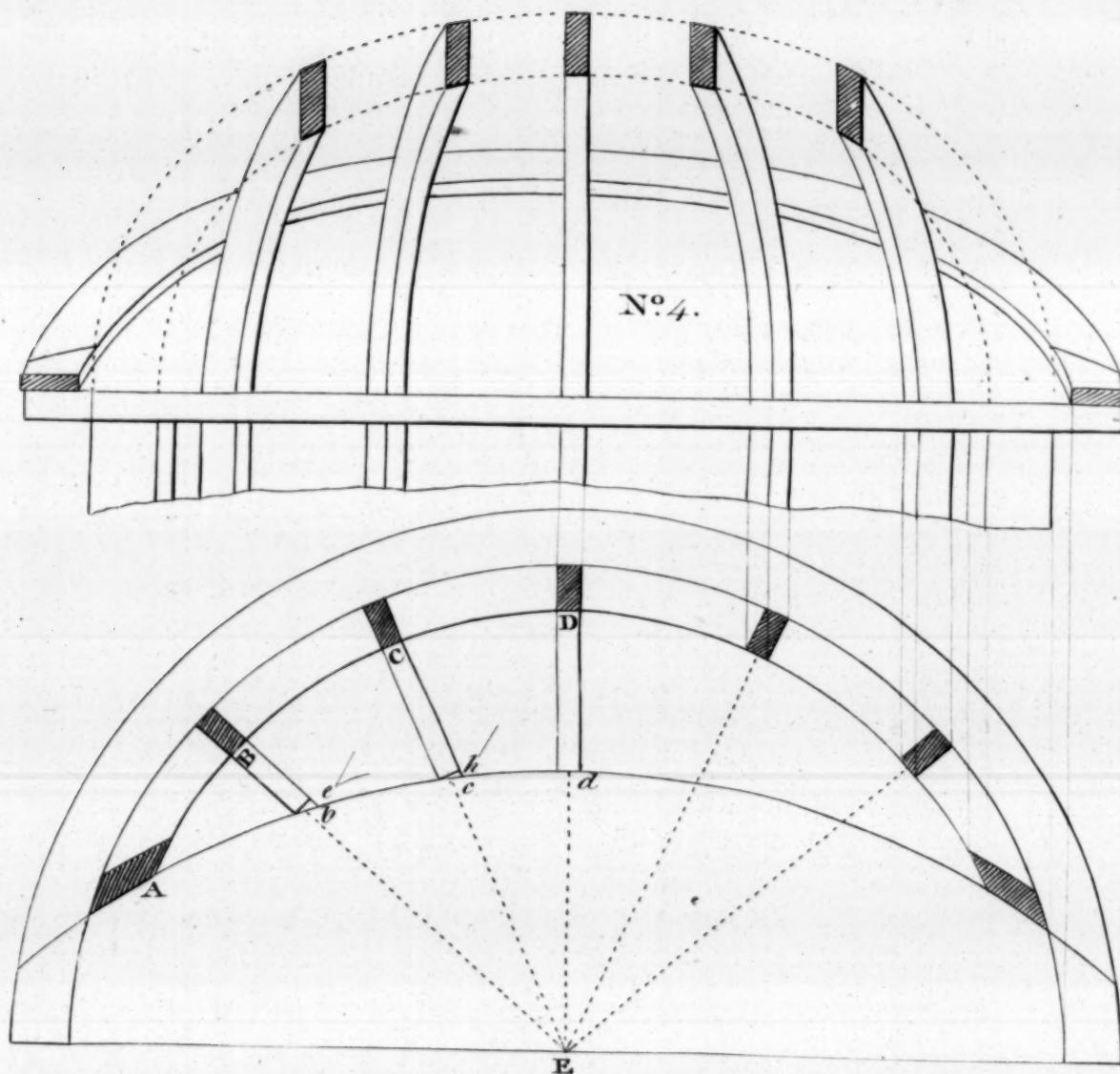


Fig. 2.









How to cut the ribs to the face of the circular wall.

From *B*, *C*, and *D*, at No. 1, No. 2, No. 3, make the distances *Bb*, *Cc*, and *Dd*, respectively equal to *Bb*, *Cc*, and *Dd*, on the plan; from the points *b*, *c*, and *d*, at No. 1, No. 2, No. 3, draw *bKp*, *cMR*, and *dNT*, respectively perpendicular to *BH*, *CG*, and *DF*, cutting their circle in *K*, *M*, and *N*; then will *BK*, *CM*, and *DN*, be the length; on the inside of each rib take the little distance *be*, *cb*, from the plan, and at No. 1, No. 2, No. 3, make *bc*, *db*, equal to them; draw *eIU*, *hLV*, respectively parallel to *bKp* and *cMR*, and the distance of the parallel lines *IU*, *Kp*, and *MR*, *LV*, will show the bevel of each rib so as to answer the face of the wall; No. 4, shows the manner of fixing the ribs, which must be perpendicular to the plan, and, to keep the ribs steady, a circular rib may be fixed across the backs, whose inside will be a part of the same circle as the back of the ribs.

OF FIXING GROUNDS.

Grounds are framed pieces of timber attached to the wall, going round windows, doors, or any other opening in buildings, in order to fix an architrave or any other kind of moulding upon them; in these cases all grounds ought to stand perpendicular to the horizon, that is, in workmen's terms, to be plumb face and edge, and great care ought to be taken in fixing them perfectly firm and solid in every part, for on their accuracy depends the well finishing of all the inside work; and if in plaister, it ought to be floated to them, and the firmly fixing of the architrave will depend much on their solidity.

In fixing grounds for windows, the fash frame ought to be carefully fixed first, and to stand quite perpendicular, or plumb; be careful that the face of the ground stand quite parallel to the face of the fash frame, and to project about three-fourths of an inch from the face of the naked brick-work, so as to leave a sufficient space for the thickness of the plaister. The edge of the ground ought to be in the same plane with the edge of the fash frame (that is, in workmen's terms, out of winding). The edge of the architrave, when finished, is to stand about three-eighths of an inch within the inner edge of the fash frame, so that a perpendicular line down the middle of the grounds, ought to stand exactly opposite to a perpendicular line down the middle of the fash frame.

LAYING OF FLOORS.

The true excellence of a floor is, that it be perfectly level; but experience teaches us that the nature of wood will not admit of its being made perfectly level, for as every floor has always a certain degree of weight in itself, so it will have a certain degree of sinking from the laws of gravitation, in those places where it is not supported, until the moisture is quite dried out of the wood, and consequently there should be a certain degree of rising or cambering in the floor (about one inch in 20 feet), so that it should be as near to a plane

D

as

as possible when it is settled, or the moisture is dried out. But notwithstanding grounds should be perpendicular, and floors horizontal, yet we are often obliged to sacrifice these perfections, to suit other conveniences, as will be shewn in the instructions for hanging doors.

PLATE XXVI.

MITERING.

FIG. 1, the method of mitering dodo together at any exterior angle of a room.

Note.—In fixing this together, you may drive in brads from each side.

FIG. 2, the method of fixing troughs together or any rectangular wooden vessel.

FIG. 3, the method of putting dodo or skirting together at any interior angle of a room; this is also used for water trunks.

FIG. 4, the manner of fixing and finishing two pieces of framing together at the angle of their meeting with a returned bead, in order that the joint should not be shewn: this is only used in common finishings; in good finishings, a small three-eighth bead is only used at the joint, keeping the angle entire. This is the beauty of joiner's work, to show all angles as sharp as possible: some finish without any bead at the joint, as in *fig. 6*, where the joint is made as close as possible and well glued together; and if it should be required to be stronger, you may glue blockings in the angle, which will keep it firm.

FIG. 5, is another method of mitering; this is not so strong as *fig. 1*, as it has no buttment.

In glueing up large work, all the edges that are to be glued, ought to be put before a fire so as to be well warmed, and then to be immediately glued, taking care at the same time that the glue is as hot as possible, for glue never holds well when it is chilled or cold.

PLATE

Framing of Angles.

Pl. 26.

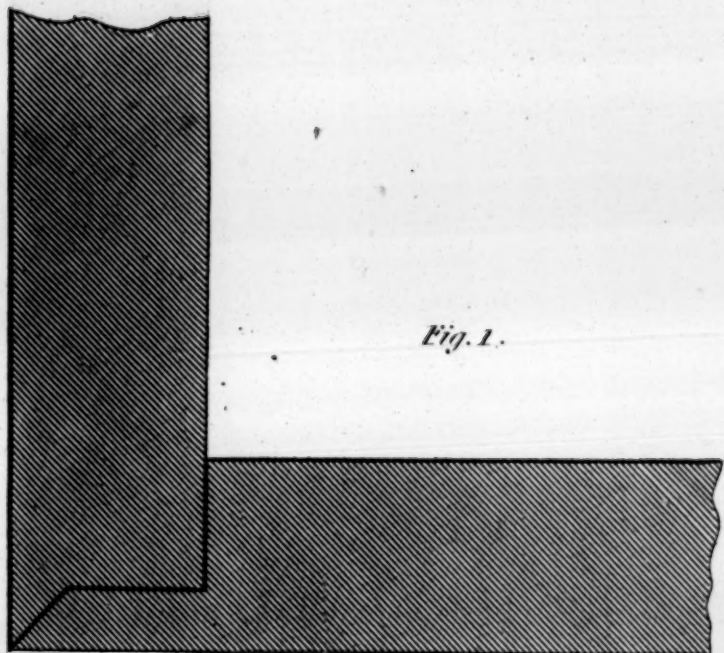


Fig. 1.

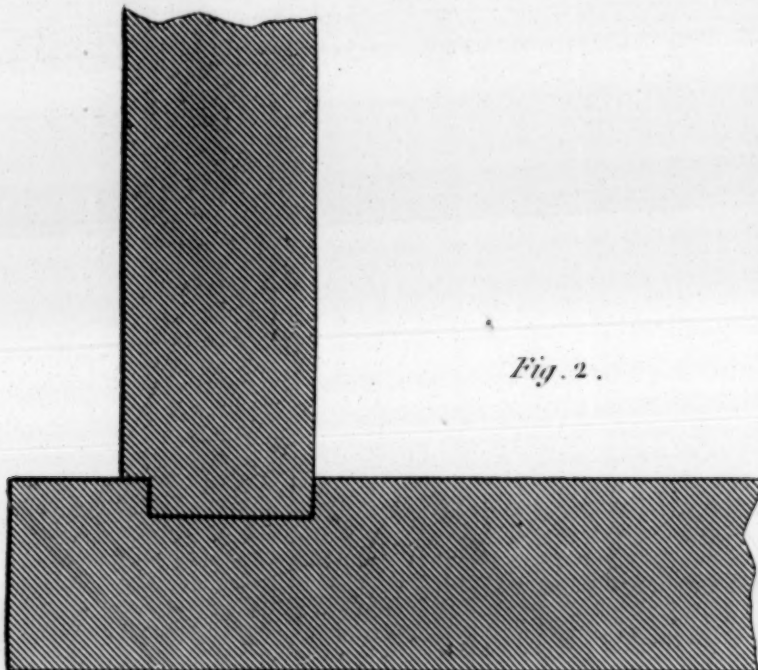


Fig. 2.

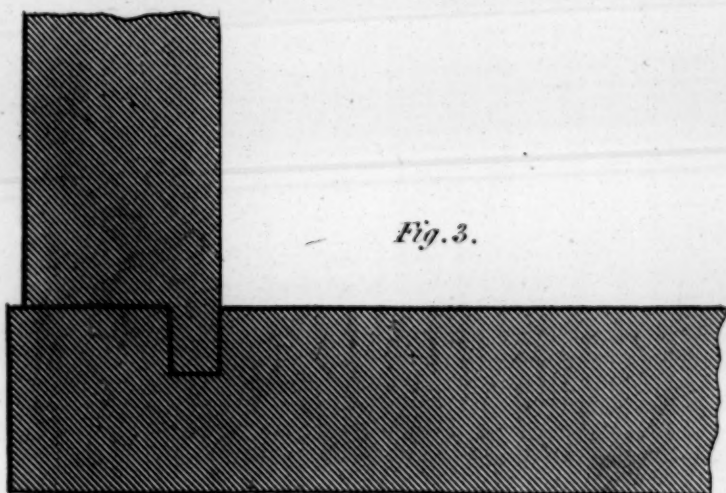


Fig. 3.

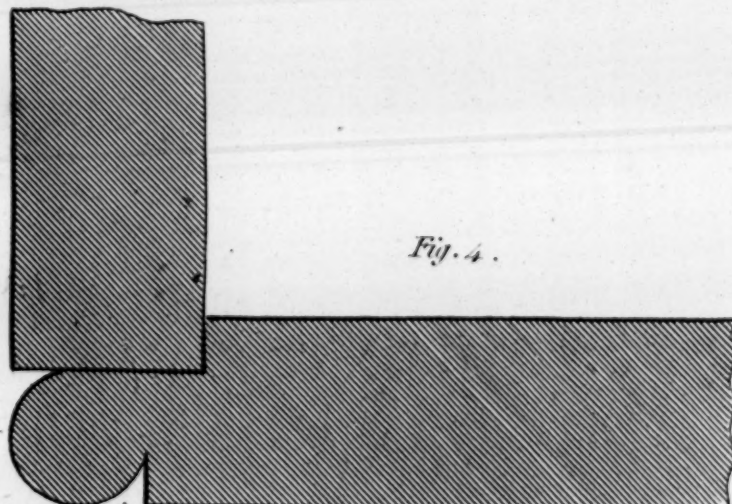


Fig. 4.

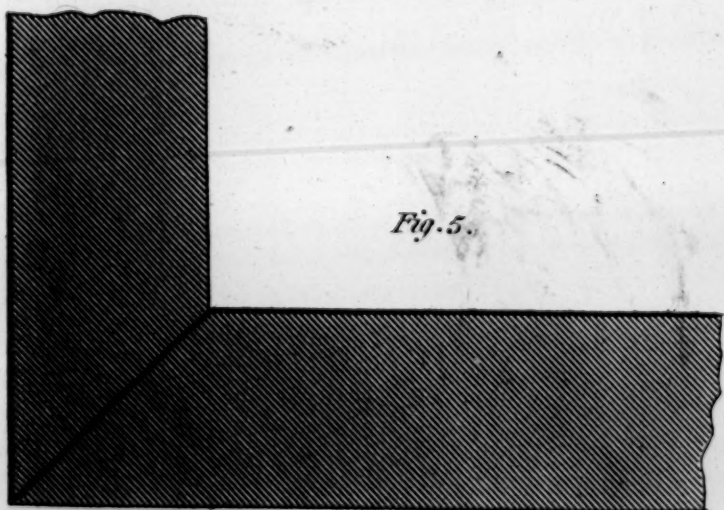


Fig. 5.

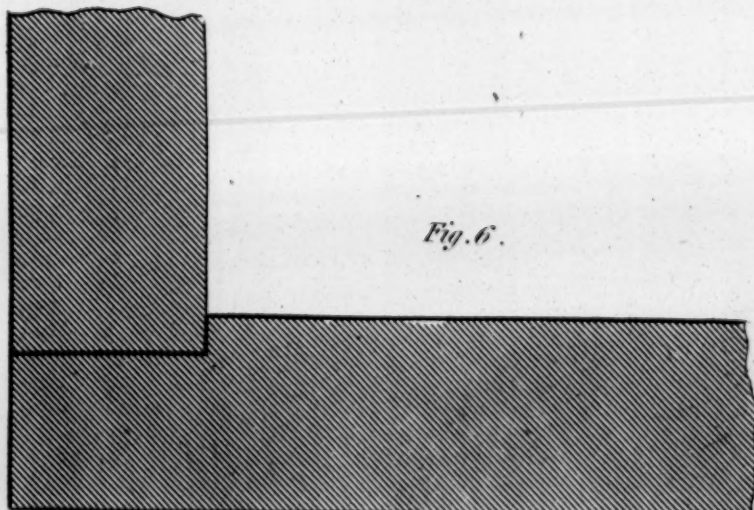
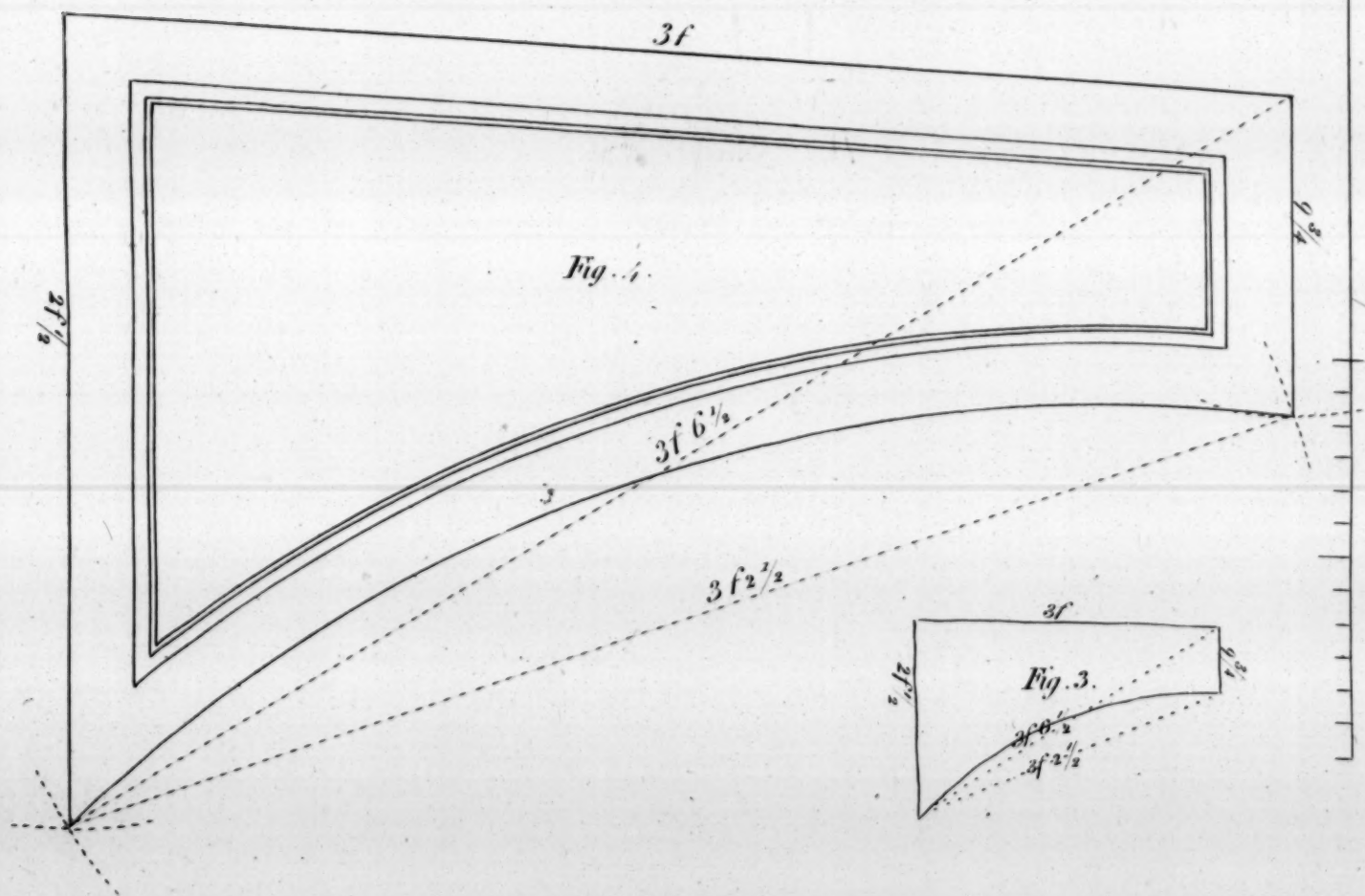
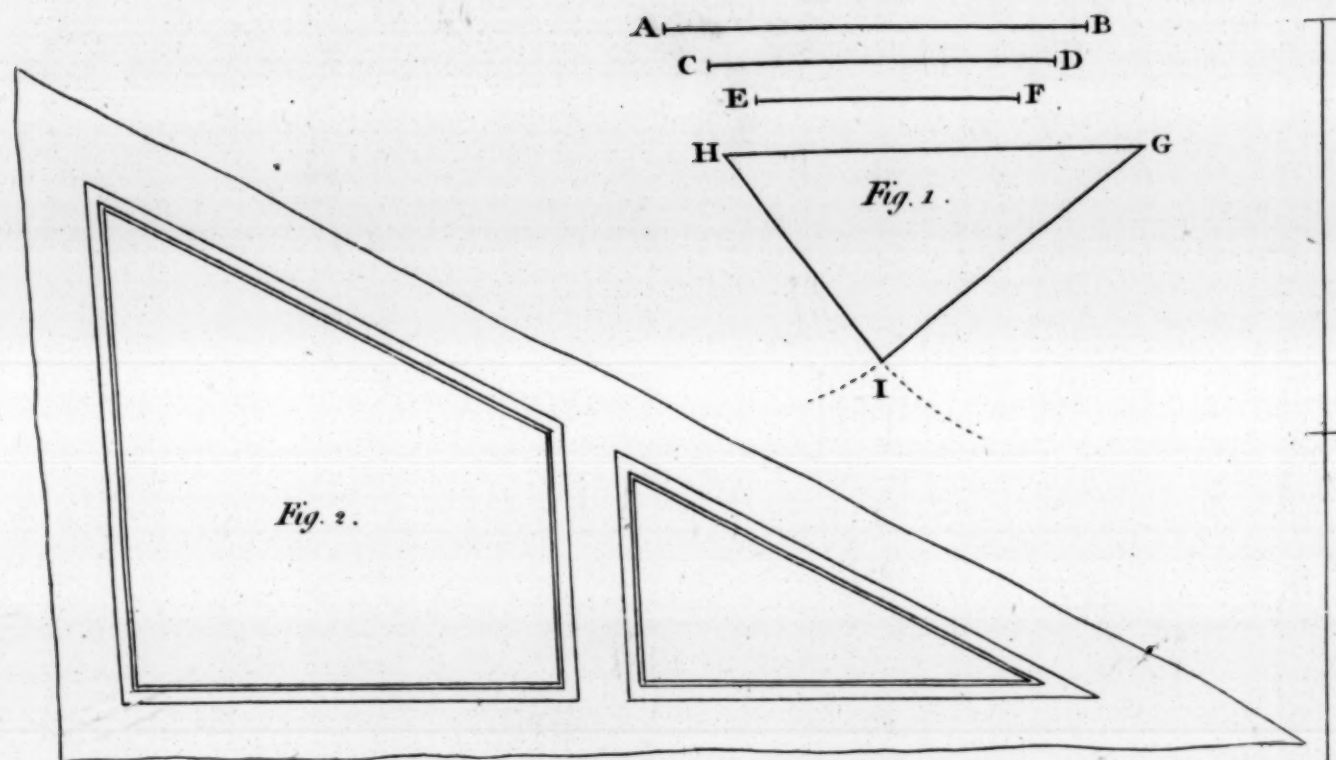


Fig. 6.









Hingeing.

Pl. 28.

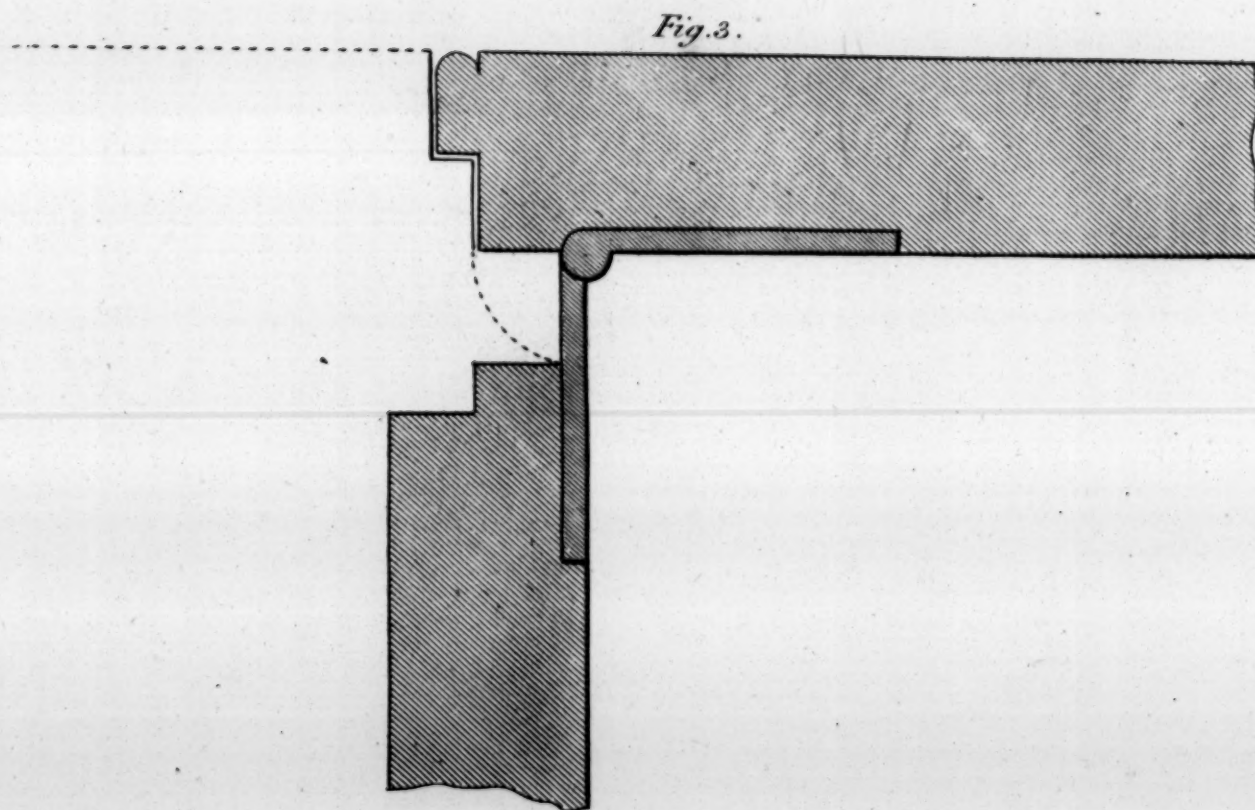
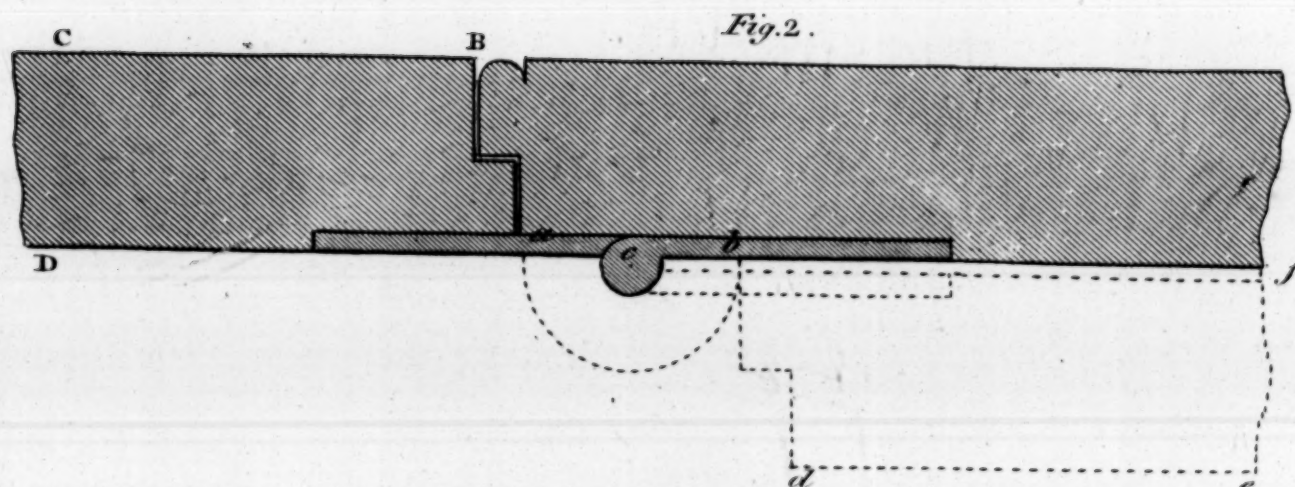
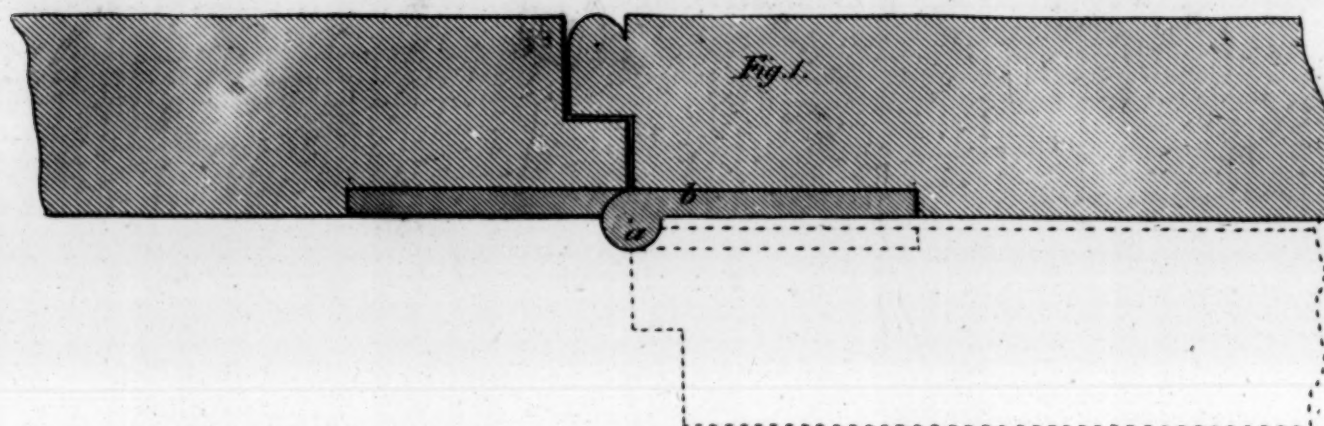


PLATE XXVII.

OF TAKING DIMENSIONS.

Three straight lines, *AB*, *CD*, and *EF*, being given to make a triangle, if any two are greater than the third,

FIG. 1, make *HG* equal to *AB* on *H*, as a centre; with a radius, *EF*, describe an arc at *I* on *G*, as a centre; with the radius *CD* describe an arc, cutting the former at *I*; join *HI* and *GI*; then will *HGI* be the triangle required.

By this rule (as fig. 2) may a piece of boarding or wainscoting be fitted into any triangular space; if the sides of the space are irregular, it will be best to fit pieces into each separately; then lay the angular points together according to their places, and you may proceed as in describing a triangle.

FIG. 3. Suppose it were required to take the measures of a soffit, without using any bevel, first make an eye drawing of it, as is shown at fig. 3; then measure the length of each side, and one of the diagonals; and if one of the sides is curved, you must measure the rise of that curve and mark on the sketch; then you may describe it as is shown in fig 4.

PLATE XXVIII.

HINGEING.

The principles of hanging doors, shutters, or flaps, with hinges.

The centre of the hinge is generally put in the middle of the joint at *a*, fig. 1; but in many cases there is a necessity for throwing back the flap to a certain distance from the joint: in order to effect this, suppose you wanted the flap, when folded back, to be at a certain distance, as *a b* in fig. 2, from the joint; divide *a b* in two equal parts at the point *c*, which will give the centre of the hinge; the dotted lines *b d e f*, shows the position when folded back.

Note.—The centre of the hinge must be placed a small matter beyond the surface of the door or shutter, otherwise the one will not fold freely back on the other.

It must also be observed, that the centre of the hinge must be on that side that the rabbet is on, otherwise it will not open without the joint being constructed in a particular form which will be afterwards shown.

FIG. 3, shows the same thing opened to a right angle.

PLATE XXIX.

OF PLACING HINGES, &c.

How to hang two flaps, or doors, so that when they are folded back, they shall be at a certain distance from each other.

This is easily accomplished by means of hinges having knees projecting to half that distance, as is plainly shown by *fig. 1*; this sort of hinges are used in hanging the doors of pews, in order to clear the moulding of the coping.

To make a rule joint for a window shutter, or for any folding flaps whatever.

Let *a*, *fig. 2*, be the place of the joint; draw *a c*, at right angles, to the flap shutter or door; take *c*, in the line *a c*, for the centre of the hinge; take the plain part *a b*, according as the workman shall think proper, on *c*; with a radius *c b*, describe the arc *b d*, then will *a b d* be the true joint.

Note. The knuckle of the hinge is always placed in the wood, because the farther it is in the wood the more of the joint will be covered, when it is opened out to a right angle, as in *fig. 3*; but if the centre of the hinge was placed the least without the thickness of the wood, it would show an open space, which would be a defect in workmanship.

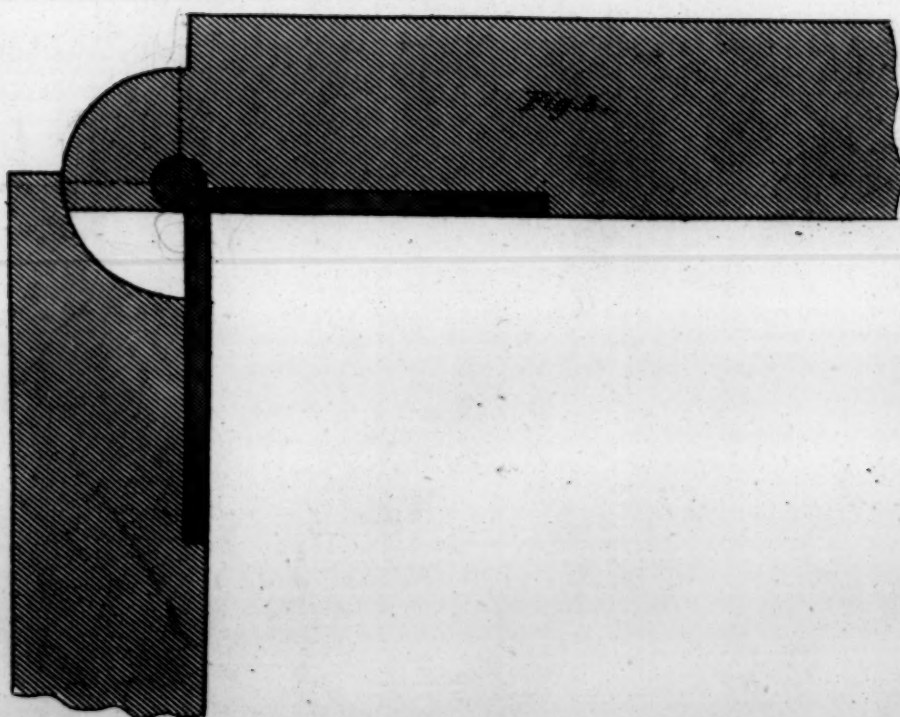
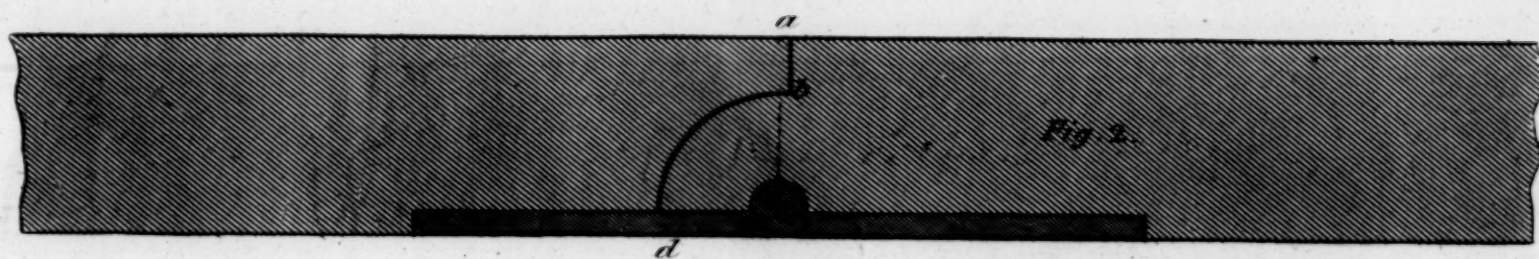
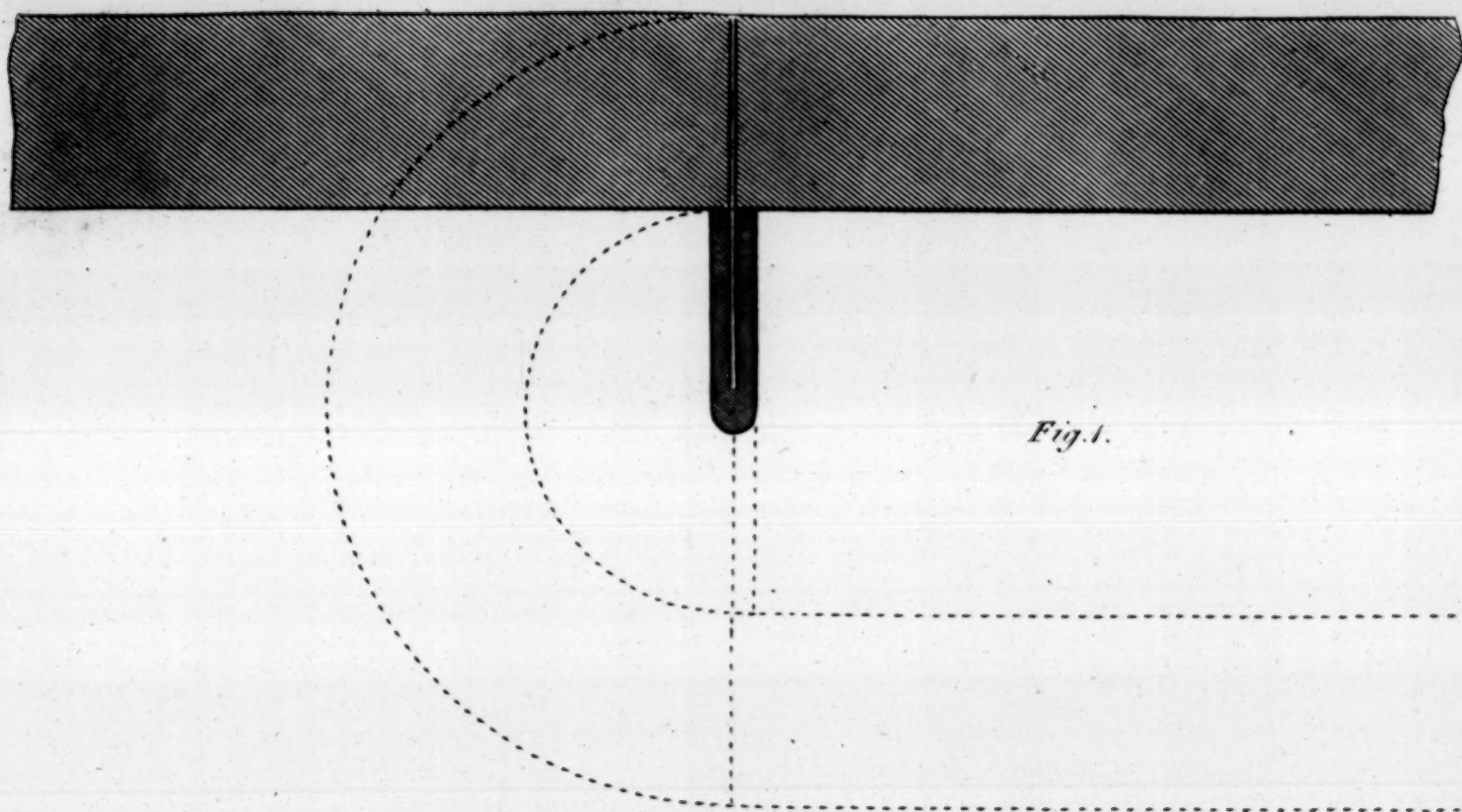
PLATE XXX.

OF PLACING HINGES, &c.

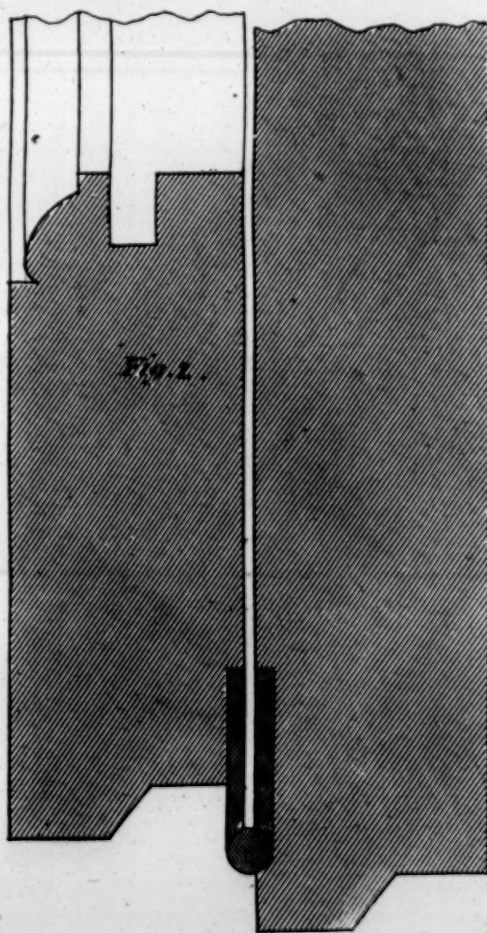
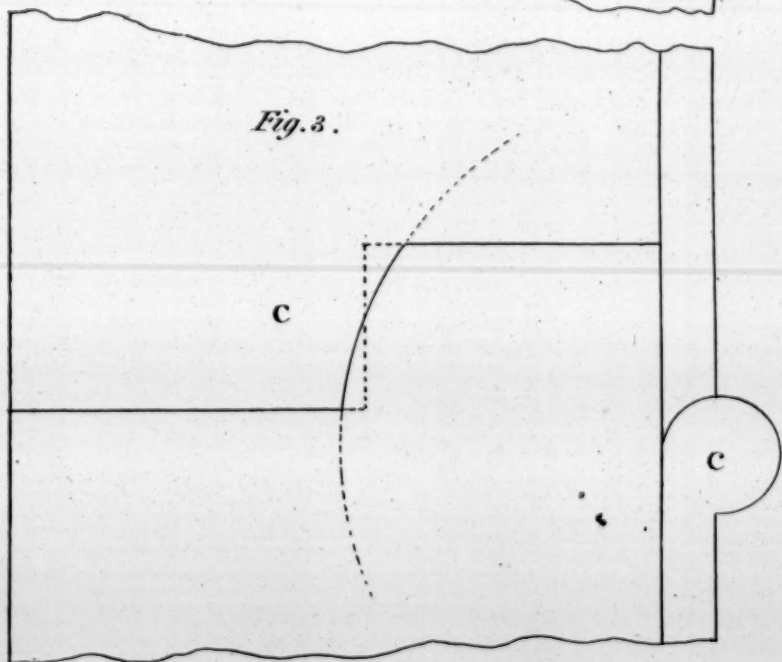
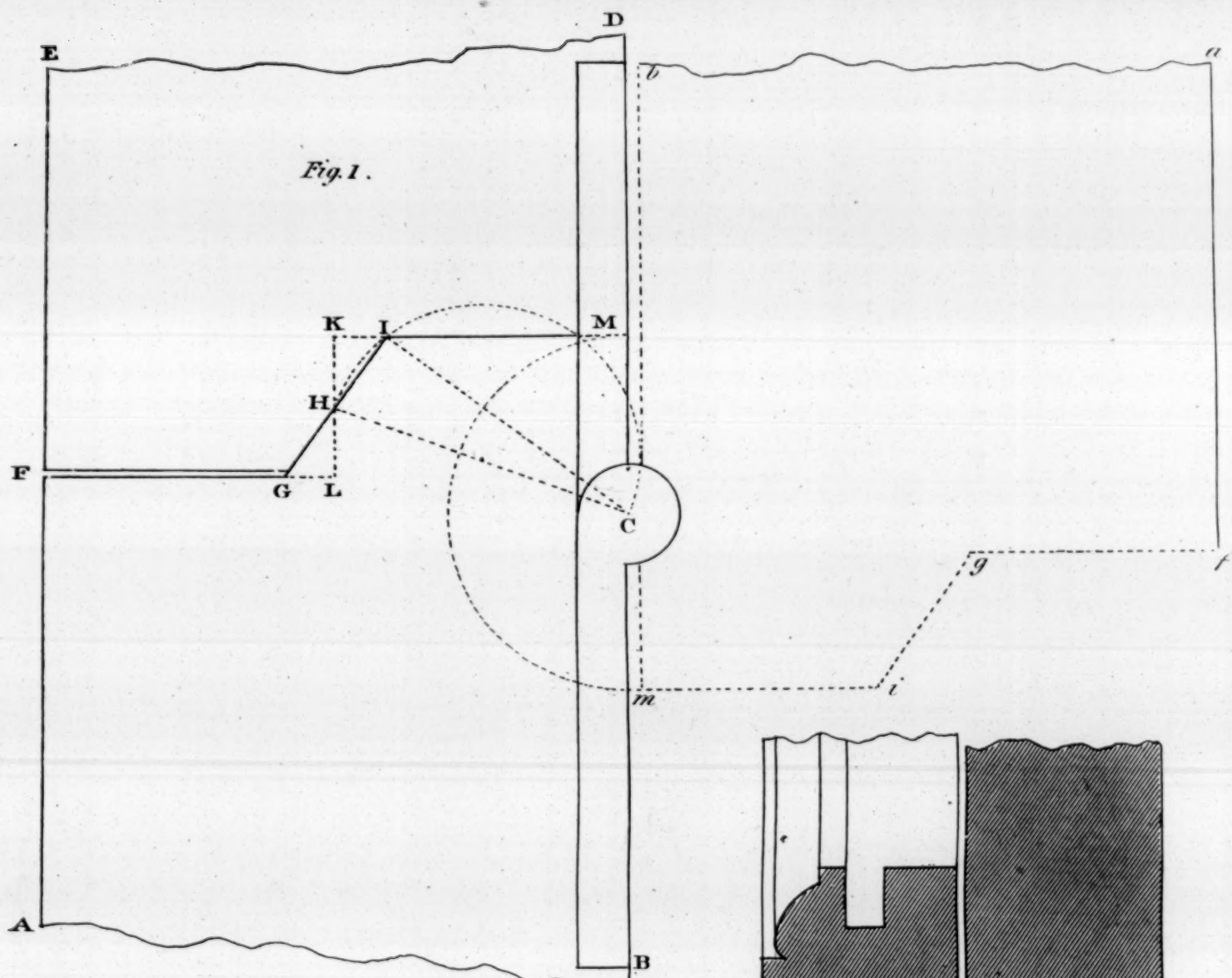
How to make the joints of styles, which are to be hung together when the knuckle of the hinge is placed on that side that the rabbet is on.

Let *C* be the centre of the hinge, *M I* the joint on the same side of the hinge; *K L* the depth of the rabbet in the middle, of the thickness of the styles, perpendicular to *K M* and *L F*, the joint on the other side, parallel to *K M*; bisect *K L* at *H*, join *H C* on *H C*, describe a semicircle *C I H*, cutting *K M* at *I*, through the points *I* and *H*; draw *I H* *G* cutting *F L* at *G*, then will *F G I M* be the true joint; but if the rabbet were made in the form *M K L F*, neither of the styles could move round the joint or hinge; *C, fig. 2*, shows the styles to one third part of the size of *fig. 1*. folded back; *fig. 3*. shows how to perform the same, by means of a circular joint, whose centre is the centre of the hinge.

PLATE











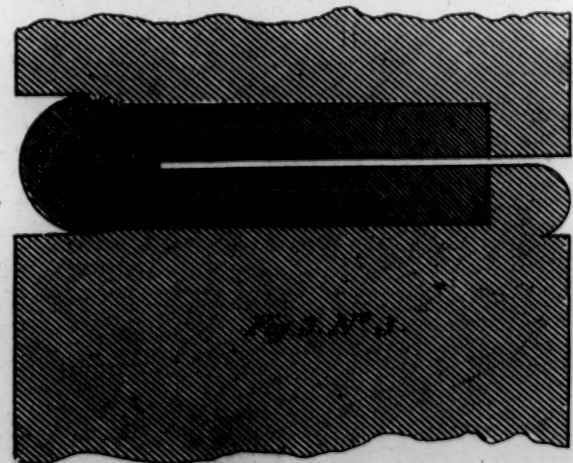
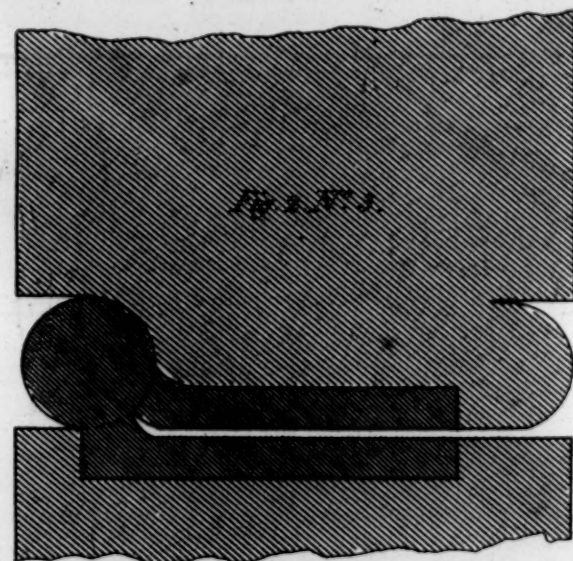
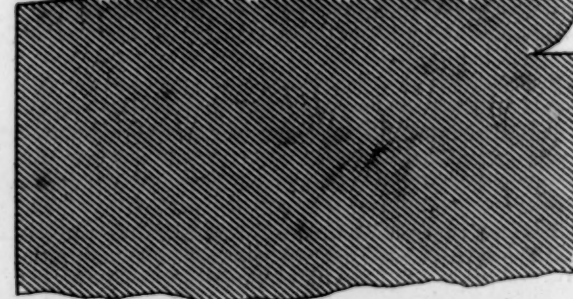
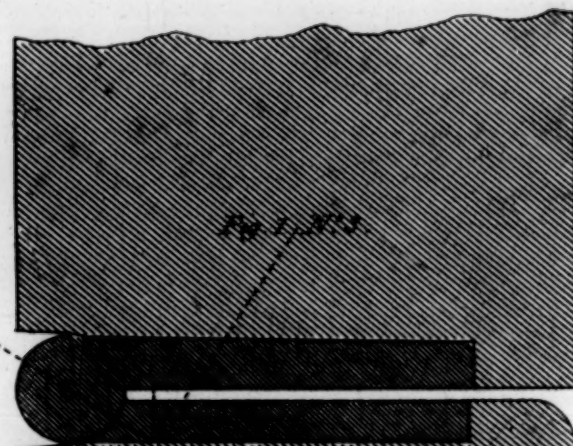
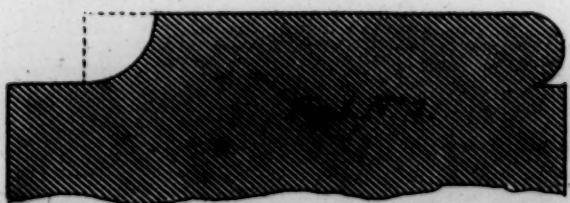
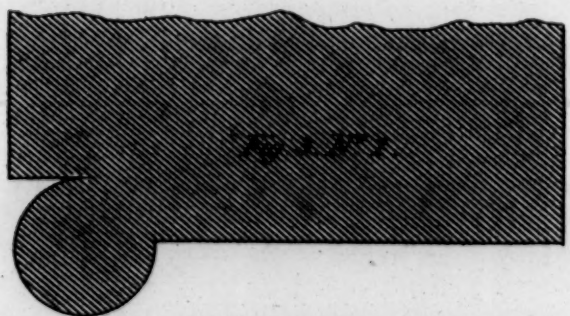
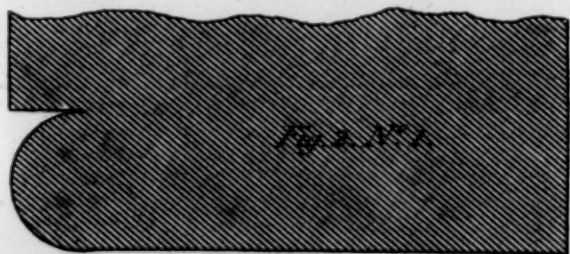
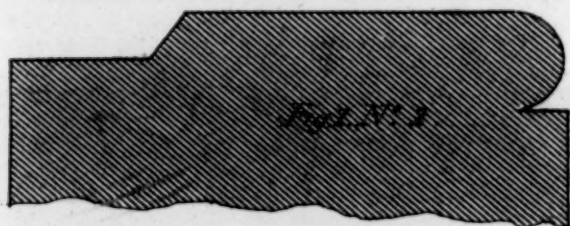
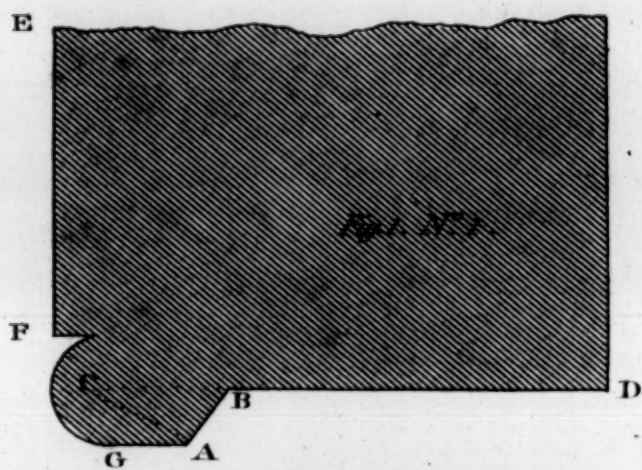


PLATE XXXI.

OF PLACING HINGES, &c.

How to form the edges or joints of door styles, that are to be hung to each other, so that the door may open to a right angle, and show a bead to correspond exactly to the knuckle of the hinge. Also the manner of constructing the hinges for the various forms of joints, so as to be let in equally upon each side.

FIG. 1, No. 1, shows the edge of a style, or it may in some cases be a jamb, on which a bead is constructed exactly to the size of the knuckle of the hinge, and rabbetted backwards, equal to half the thickness of the bead: the manner of constructing the rabbet will be shown as follows:

Through C , the centre of the bead, which must also be the centre of the hinge, draw CBD perpendicular to EF ; draw AG parallel to it, touching the bead at G ; make GA equal to GC , the radius of the bead; join CA ; make AB perpendicular to AC , cutting CD at B , then will $GABD$ be the joint required.

No. 2, fig. 1, shews a part of the hanging style constructed so as to receive the edge of No. 1.

No. 3, fig. 1, shows the above hinged together, with common butt hinges.

Note. It must be observed in this, and all the following examples of hinges, that the joints are not made to fit exactly close, as there must be allowed in working sufficient space for the paint.

FIG. 2, No. 1, and 2. The manner of constructing these, being only a plain joint at right angles to the face of the style, no farther description is necessary.

FIG. 2, No. 3, shows No. 1, and 2, hinged together, and shows the particular construction of the hinge so as to be seen as a part of the bead, and the strap part of the hinge to be let equally into each style; this construction of the hinge will admit of a bead of the same size exactly opposite to it.

FIG. 3, No. 1, and No. 2. The manner of constructing the edges of styles to be hinged together with common butts, to be let equally into each style: the manner of constructing this joint is so plain, by the figure, that it would be useless to give a description of it. No. 3, the two pieces hinged together.

PLATE XXXII.

OF PLACING HINGES, &c.

Methods of jointing styles together so as to prevent seeing through the joints, each side of the styles to finish with beads of the same size exactly opposite to each other, and for the strap part of the hinges to be let in equally into both parts or styles.

FIG. 1, No. 1, and 2, the manner of constructing the joint before hinged together.

FIG. 1, No. 3, shows No. 1, and 2, hinged together with hinges made in the form of common butts.

FIG. 2, No. 1, and 2, shows another method of constructing the joints before hinged together.

No. 3, shows No. 1, and 2, put together, and the particular form of the hinges for the joint.

PLATE XXXIII.

OF PLACING HINGES, &c.

The principle of concealing hinges, showing the manner of making them, and of forming the joint of the hanging style, with the other style connected to it by the hinges, either for doors or windows.

FIG. 1, for a window.

A, inside bead of the sash frame.

B, inside lining.

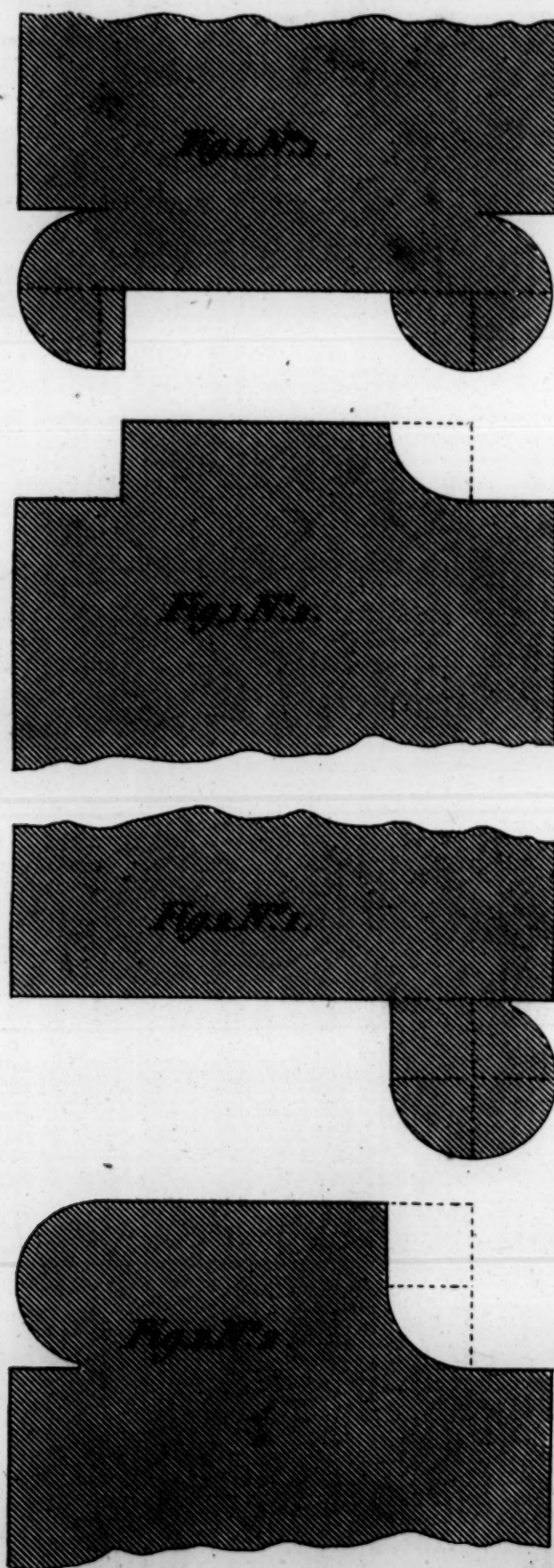
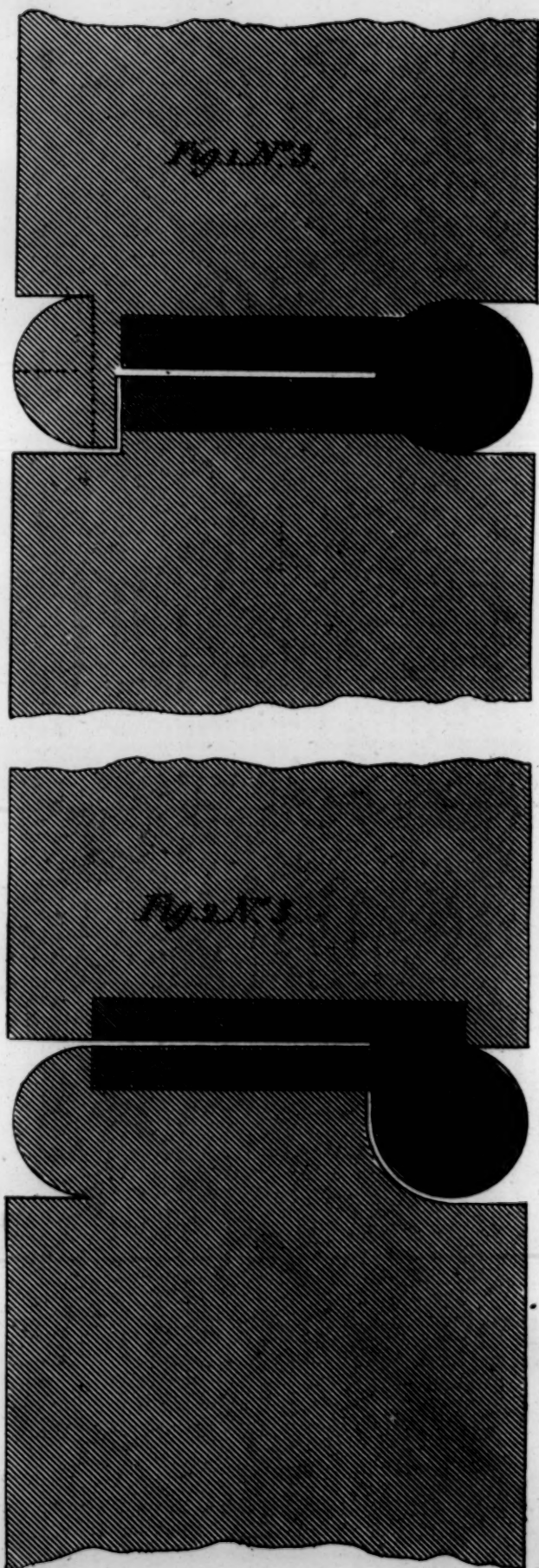
C, style of the shutter.

Let *a* be the intersection of the face of the shutter, or door, with that of the inside lining of the sash frame.

a r the face of the inside lining.

Bisect the angle *p a r* by the right line *a a*; now the centre *c* being determined in that line, so that the knuckle of the hinge may be at a certain distance from the face *p a* of the shutter; through *c* draw the line *d d*, at right angles to *a a*; then one side of the hinge must come to the line *c d*, the hinge being made as is shewn by the figure.

How





Hingeing.

Pl 33.

Fig. 1.

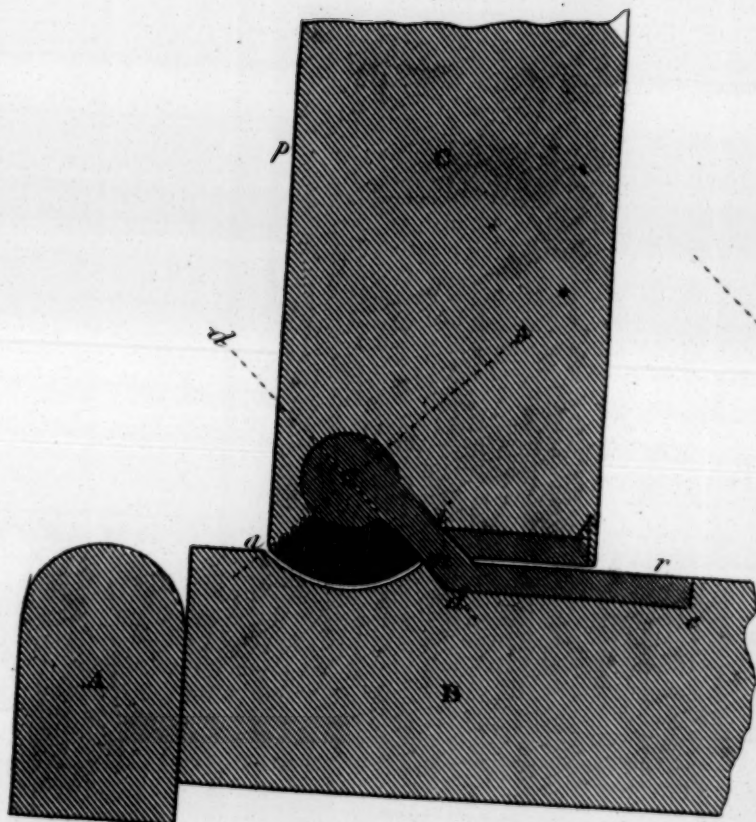


Fig. 2.

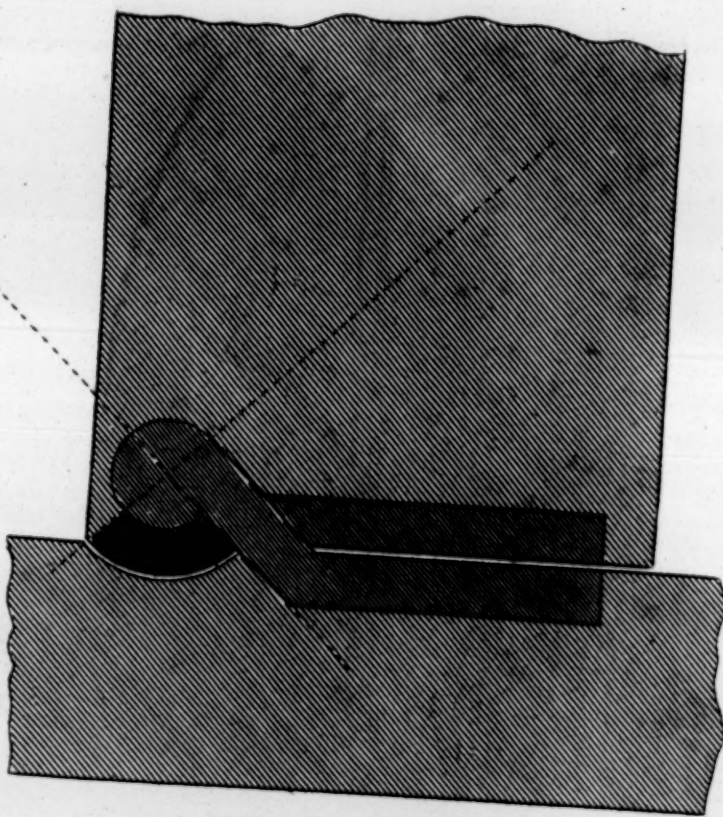


Fig. 3.

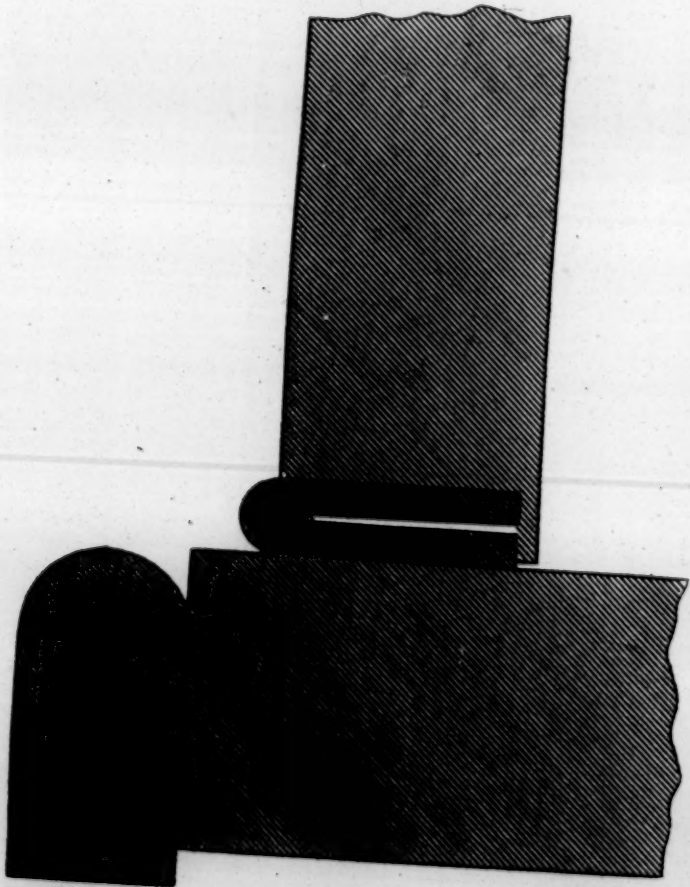
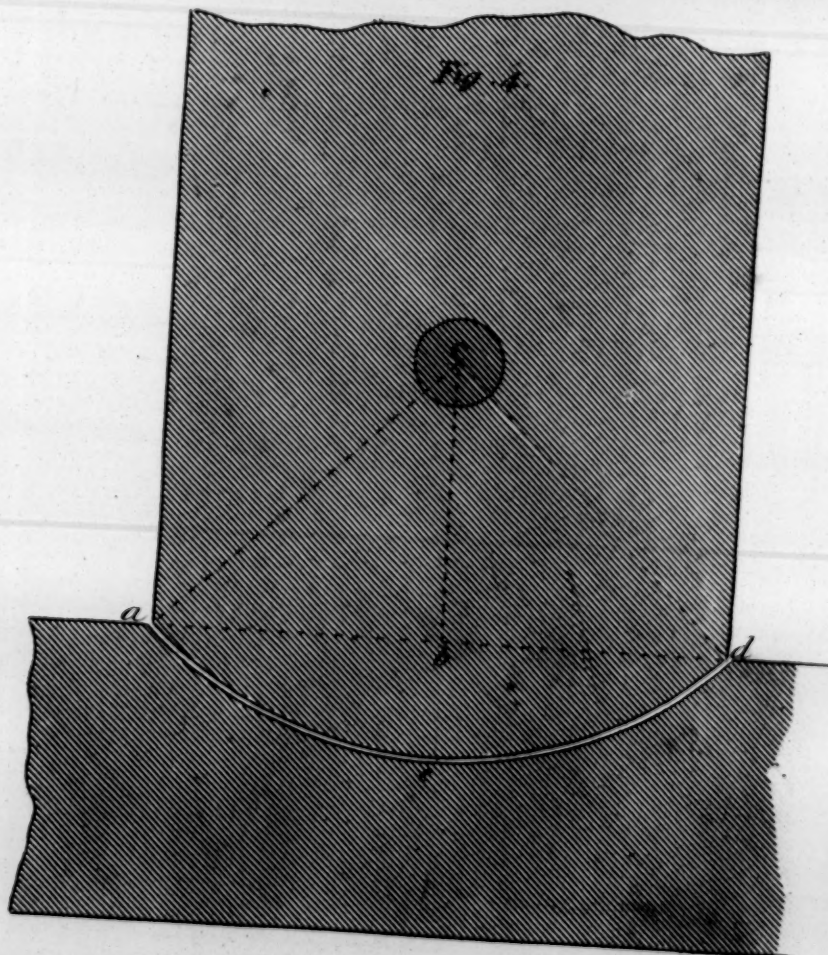
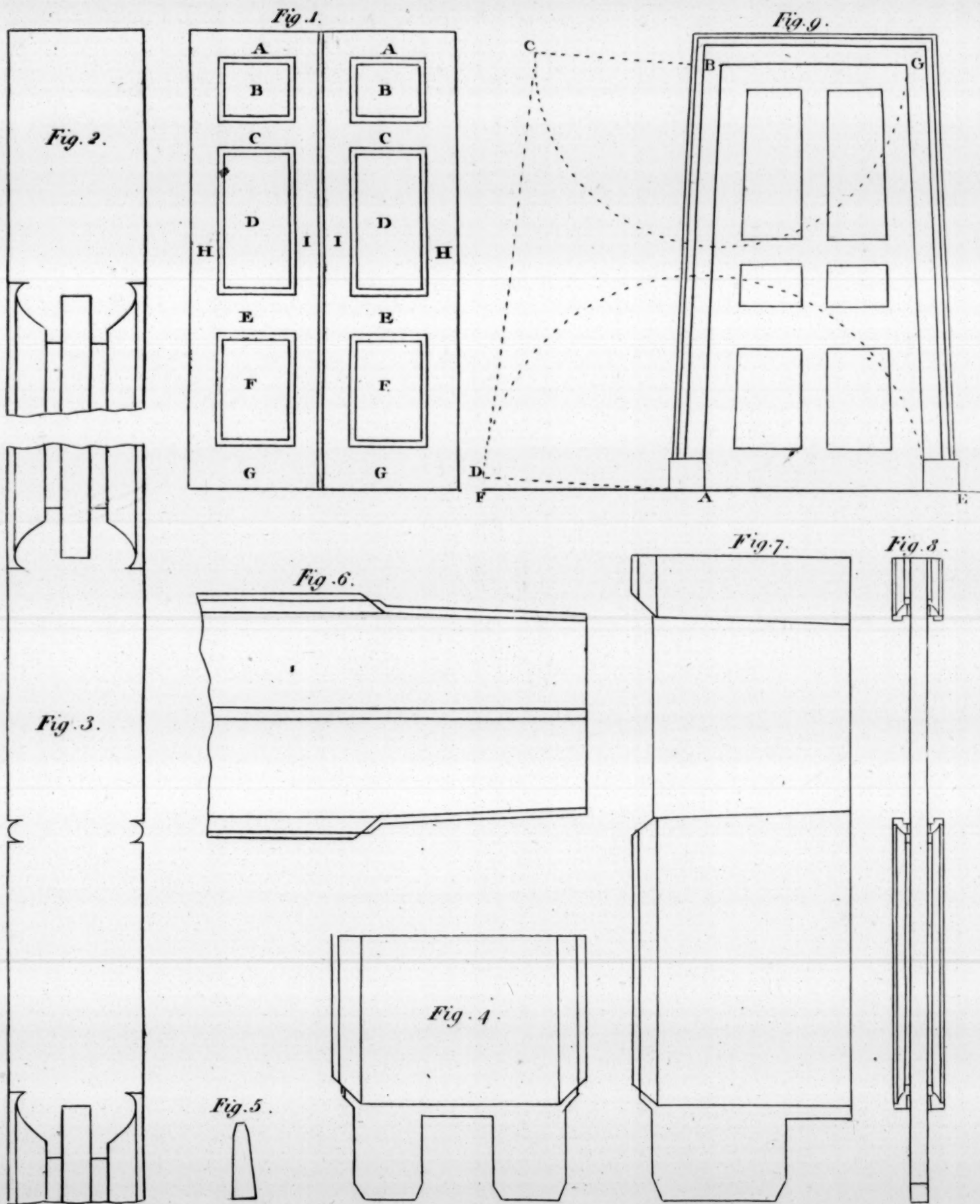


Fig. 4.









How to construct the jamb to be clear of the shutter.

On c , as a centre, with a radius ca , describe an arc, am , and it will be the joint required.

Note. When these sort of hinges are used in shutters, the strap part of the hinge may be made longer on the inside lining, than that which is connected with the shutter.

FIG. 2, is the manner of hanging a door on the same principle: the shadowed part must be cut out, so that the other strap of the hinge may revolve; the edge, cd , of the hinge, will come into the position of the line aa , when the window is shut in.

Here the strap part of the hinge may be of equal lengths.

FIG. 3, the common method of hanging shutters together, the hinge being let the whole of its thickness into the shutter, and not into the sash frame.

By this mode it is not so firmly hung, as when half is let into the shutter and half into the sash frame, provided the inside lining is of sufficient thickness.

Note. The centre of the hinge in this must be in the same plane with the face of the shutter, or beyond it, but not within the thickness.

FIG. 4, the method of hanging a door with centres. Let ad be the thickness of the door, and bisect it in b ; draw bc perpendicular to ab ; make bc equal to ba , or bd ; on c (the centre of the hinge) with a radius ca , or cd , describe an arc; aed will give the true joint for the edge of the door to revolve in.

PLATE XXXIV.

OF DOORS.

The method for making double margin doors.

FIG. 1, A, A , top rails.

B, B , top, or frize pannels.

C, C , frize rails.

D, D , middle pannels.

E, E , Lock, or middle rail.

F, F , bottom pannels.

G, G , bottom rails.

H, H , outside styles.

I, I , middle style, showing two styles.

This door is a kind of deception for a pair of folding doors; it is frequently used for an outside door, where the door is wanted to open all on one side.

In

In order that this sort of door may appear a complete deception, there will be some difficulty in making and putting on the furniture; to accomplish this, the lock may be constructed with a long bar, or rod, to reach from one of the middle styles to the jamb; and the rail itself may be glued up hollow, so that the bar of the lock, and bolts, may work as easy as possible.

FIG. 2, section of the style *HH*, with part of the plan of one of the rails.

FIG. 3, section of the middle style; this and *fig. 2*, are shown to a larger scale than the following.

FIG. 4, part of the lock rail, showing the double tenon which goes into the style.

FIG. 5, one of the wedges that wedges the styles and rails together.

FIG. 6, part of the middle style, showing the tenon which goes into the bottom rail, *fig. 7*: this tenon is made double.

FIG. 7, part of the bottom rail, showing how it is made to receive the middle style.

FIG. 8, the thickness of *fig. 7*, showing the wood that is left in the middle to receive the tenon of *fig. 6*.

To find how far a door made in the manner of fig. 9, will clear the floor, when opened to a right angle.

FIG. 9. Make the angle *BAD*, equal to the angle *BAE*; make *AD* equal to *AE*; also make the angle *ABC* equal to the angle *ABG*, and make *BC* equal to *BG*; join *DC*; then will *ABCD* be the true position of the door.

And the angle *DAF*, will be double the angle that the bottom of the door will make with the floor, when it is opened to a right angle.

OF HANGING DOORS.

Having treated thus fully on the various kinds of hinges adapted to sundry purposes, before I conclude the subject, it may be proper to make a few observations upon, and to give some rules for, hanging of doors, so as to clear the ground or carpet.

1st. Raise the floor under the door as much as may be necessary, according to the thickness of the carpet, &c.

2d. Make the knuckle of the bottom hinge to project beyond the perpendicular of the top hinge about one-eighth of an inch, this will throw the door off the floor.

Note. The centre of the top hinge must project a little beyond the surface of the door, if the hinge is let equally into the door and into the jamb; otherwise, if the centre lay in the surface of the door, it ought to be placed at the very top, which is seldom done.

3d. Fix the jamb, on which the door hangs, away from the plumb-line, so that the top of the jamb may incline to the opposite jamb about one-eighth part of an inch, this will have the effect to clear the door off the floor.

4th. Make the door, when shut, to project at the bottom towards the inside of the room, about one-eighth of an inch, which may be effected by giving the rabbet the quantity of inclination requisite.

Note

Note.—Although any of the above methods properly applied will make a door swing sufficiently clear of the floor, yet as each one separately will require to be done in so great a degree as to offend the eye, I do not recommend them in nice work, but would rather advise a combination of them all to be used, thus:

Raise the floor about one-eighth of an inch under the door; make the jamb on which the door hangs incline to the opposite jamb about one-eighth of an inch; make each rabbet that stops the door project at the bottom one-eighth of an inch to that side of the room on which the door opens. Now these several methods practised in the above small degrees, which will not be perceptible, will throw the door sufficiently out of the level when opened to a square; that is, it will be at least half an inch when the height of the door is double its width. Again,

5th. An invention has lately been introduced called *Rising Hinges*, which are made with a spiral groove winding round the knuckle; but as this method introduces an error in workmanship, I cannot well recommend it, for the door ought to be close fitted in, except sufficient room for the painting (for which workmen usually allow a space the thickness of a half crown), and as the door is continually rising on the spiral groove, it will be necessary either to cut away part of the hanging stile at top, or else to cut the soffit to allow room for the door to rise on the hinge; this, when the door is shut, has an awkward and unworkman-like appearance.

6th. This purpose would be completely answered by adopting a door in the form of the antique doors; that is, the bottom to be wider than the top, the jambs having the same inclination. This figure is introduced, not for the purpose of its being adopted in general uses, though it will clear the ground sufficiently, and it will fall to of itself; its properties are,

FIG. 9. Make the angle BAD equal to the angle BAE ; make AD equal to AE ; also make the angle ABC equal to ABG , and make BC equal to BG , join DC ; then will $ABCD$ be the true position of the door when folded back, and the angle DAF will be double the angle that the bottom of the door will make with the floor when it is opened to a right angle.

7th. For common or ordinary purposes, such as warehouse or shop doors, &c. the following easy method is useful, as it will sufficiently clear the ground, and the door will always fall to of itself.

The top hinge may be a common butt hinge, the bottom one must have a knee to project out, these hinges must be placed in such a manner, as that a line drawn through their axis shall touch the door at the top and cut the floor beyond the surface of the door an inch and a half or more, according to circumstances.

There is another kind of hinge which is applicable to gates or rough work; the upper hinge may be of the common construction, but the lower one is made with a circular knee, and is fixed in the partition out of the plane of the joint of the door; the axis of the hinges, as in the former case, must be in a line with the top of the door, gate, &c.

PLATE XXXV.

OF DOORS.

How to find the true bevel for hanging any door.

FIG. 1. Let a be the centre of the hinge; on the width of the door $a b$ describe a semicircle $b c e d a$, cutting the other side of the door at c and d . Join $a d$ and $b c$, which will be the proper edges of the door, in order to make it open freely.

Note.—The bevelling on the side $a d$ is of no other consequence than to make the sides uniform.

How to find the joint for a pair of folding doors.

FIG. 2. Let h and g be the centre of each hinge; bisect $h g$ by a perpendicular $a b$, cutting the thickness of the door at a and b ; bisect $a b$ by the perpendicular $c d$ at e ; make $e c$ and $e d$ each equal to half the thickness that you intend the rabbet to be. Suppose you intended the flap $g a c d f$ to open; draw a line from d to the centre of the hinge at g ; on $d g$ describe a semicircle $d f i g$, cutting the other side of the door at f ; join $f d$, and through c draw $c k$ parallel to it; then $k c d f$ will be the proper joint.

Note.—If you put a bead at the joint, it ought to be exactly in the middle of the door.

PLATE XXXVI.

OF DOORS.

How to find the bevel on the edge of a door when it is executed on a circular plan, and the door to turn out on the convex side of the circle.

With regard to the circular door, *fig. 1*, all that is required is to make the angle $a b c$ either a right angle or greater than a right angle (for a right angle is the least that any door will admit of) formed by the edge of the door, and a line drawn from the centre of the hinge to the opposite angle.

For the folding doors.

FIG. 2. Let a and b be the centres of the hinges on the plane; join the points a and b by the right line $a b$ and bisect it by a perpendicular $c d e$ at c , cutting the thickness of the

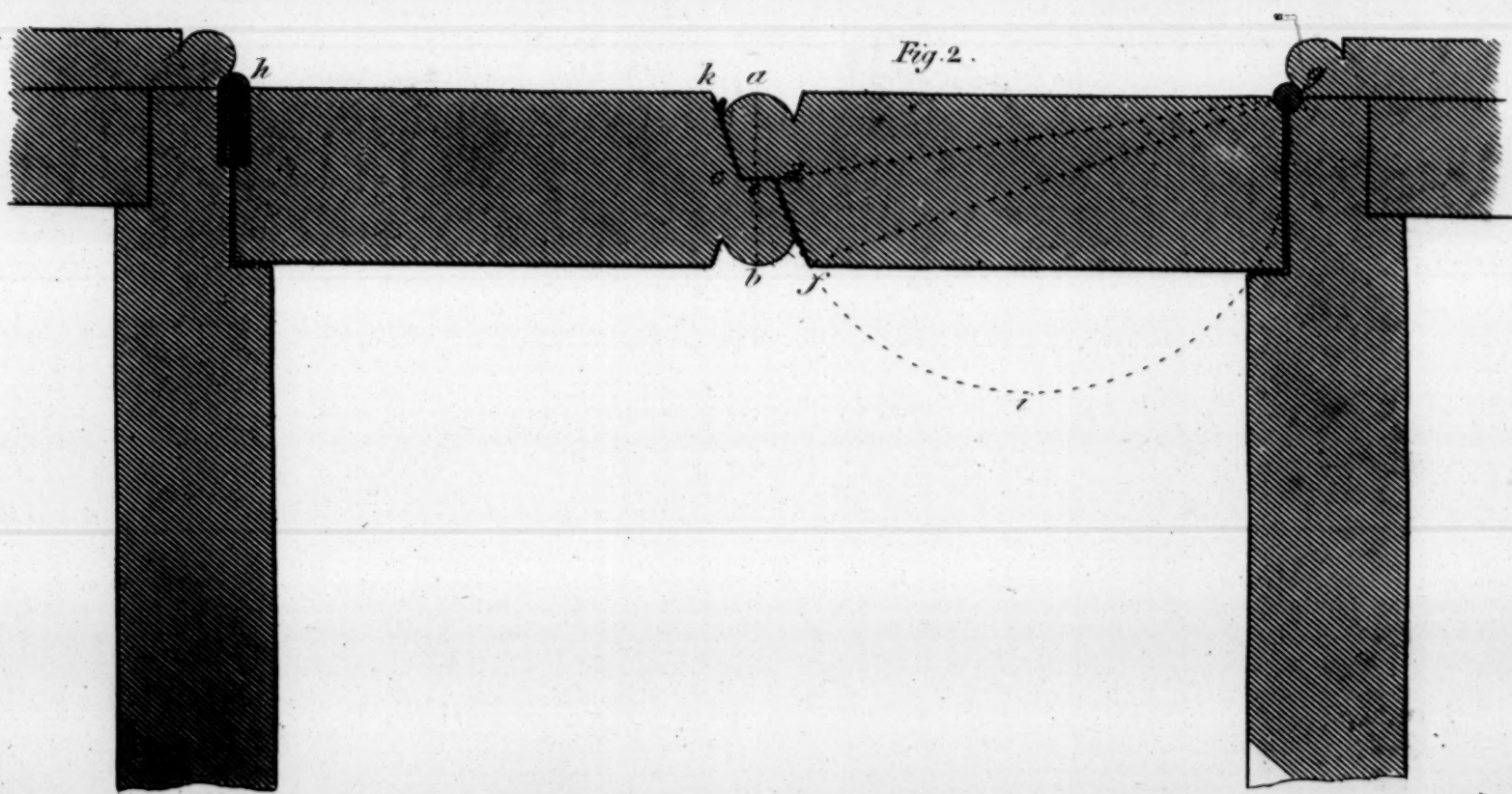
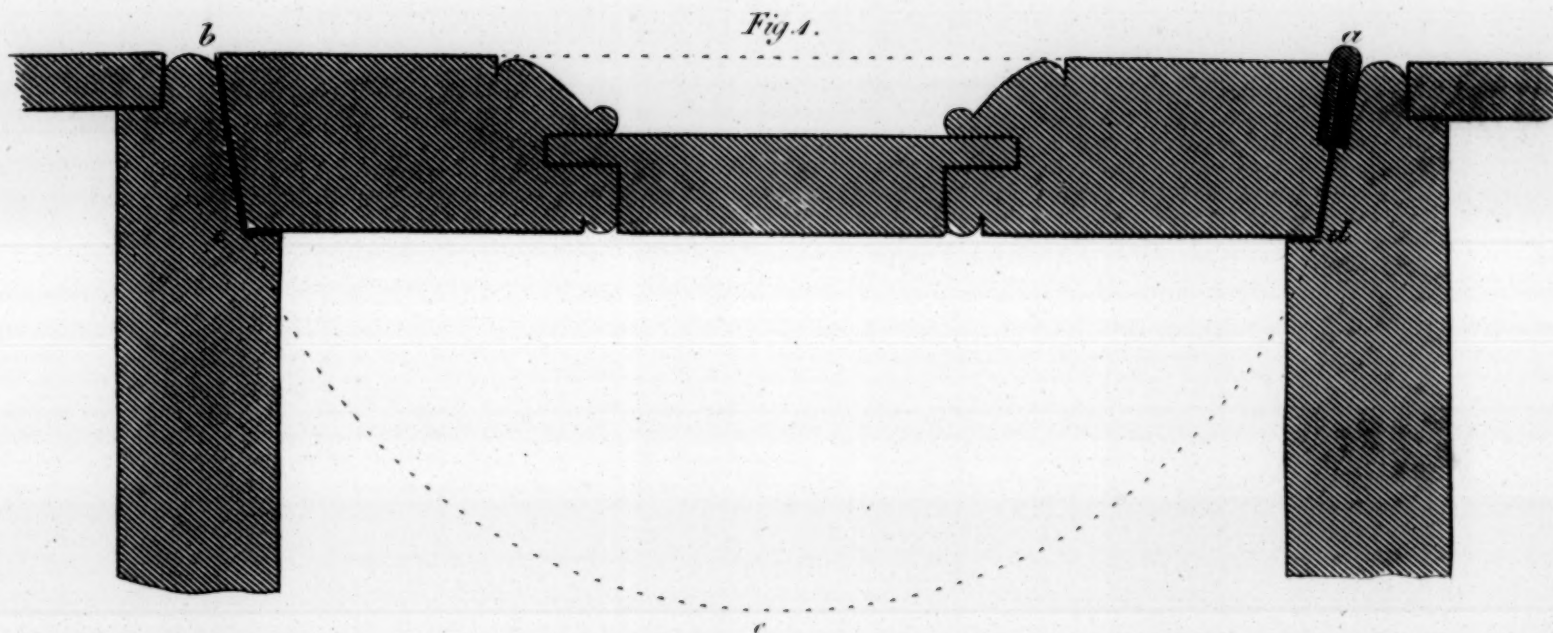




Fig. 1.

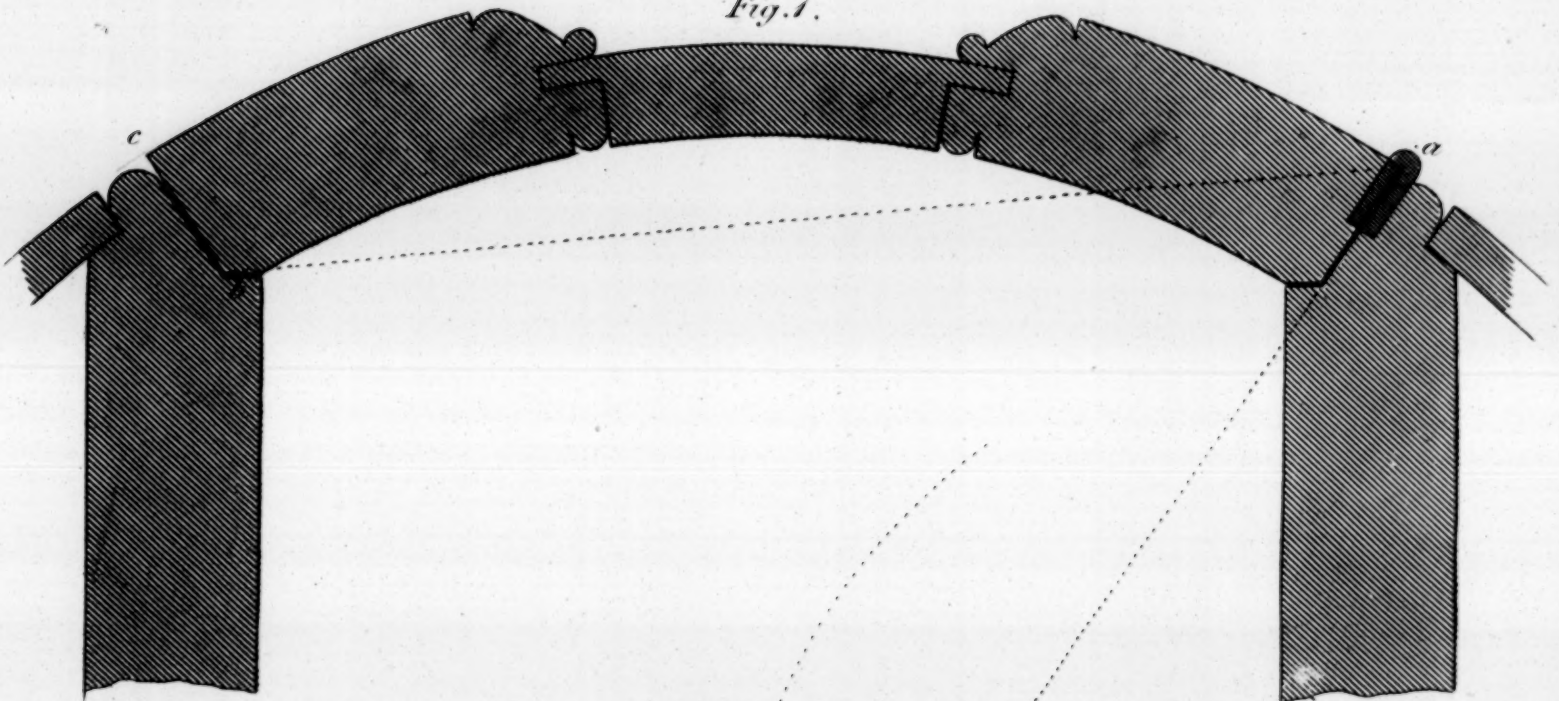
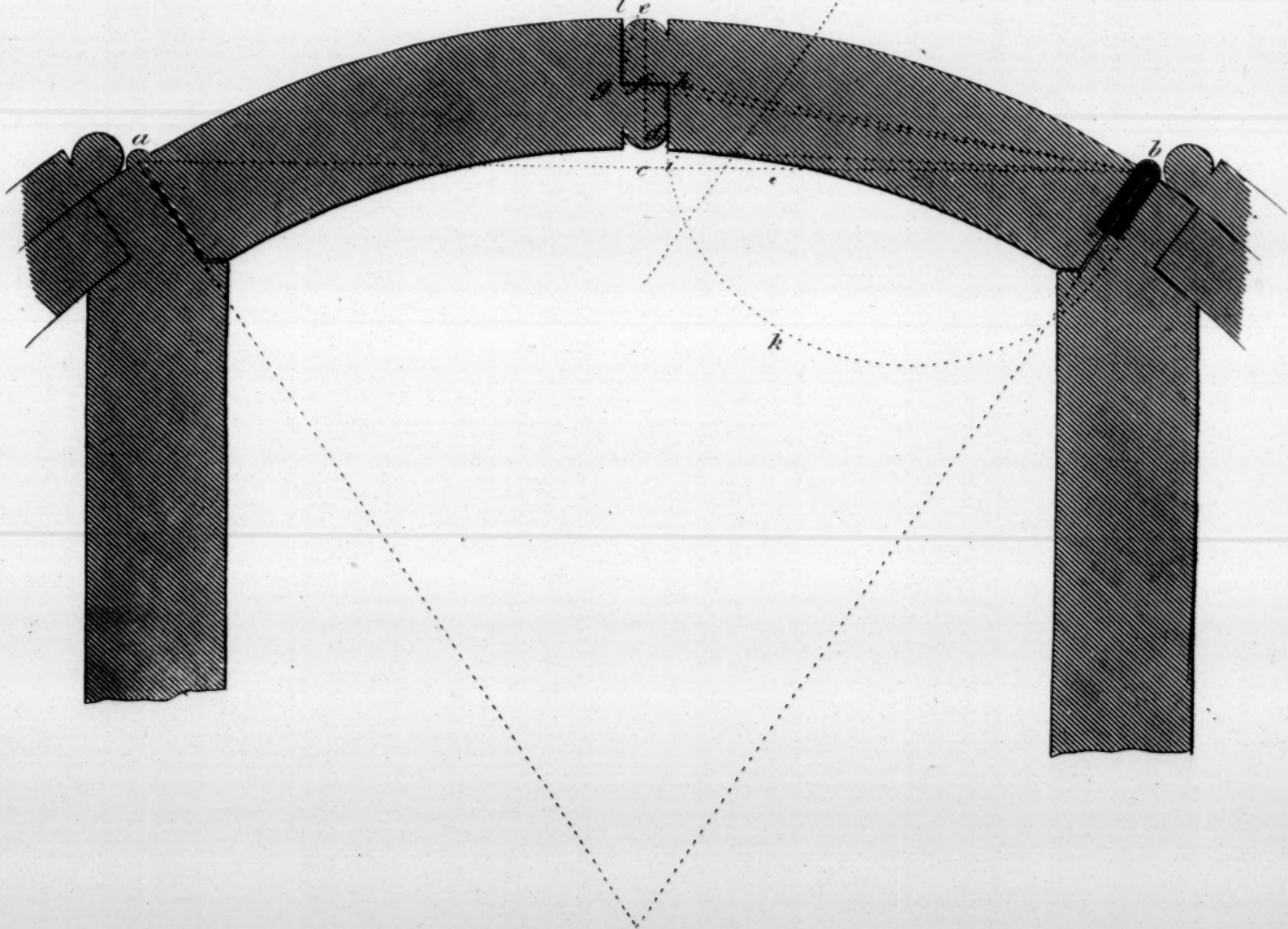
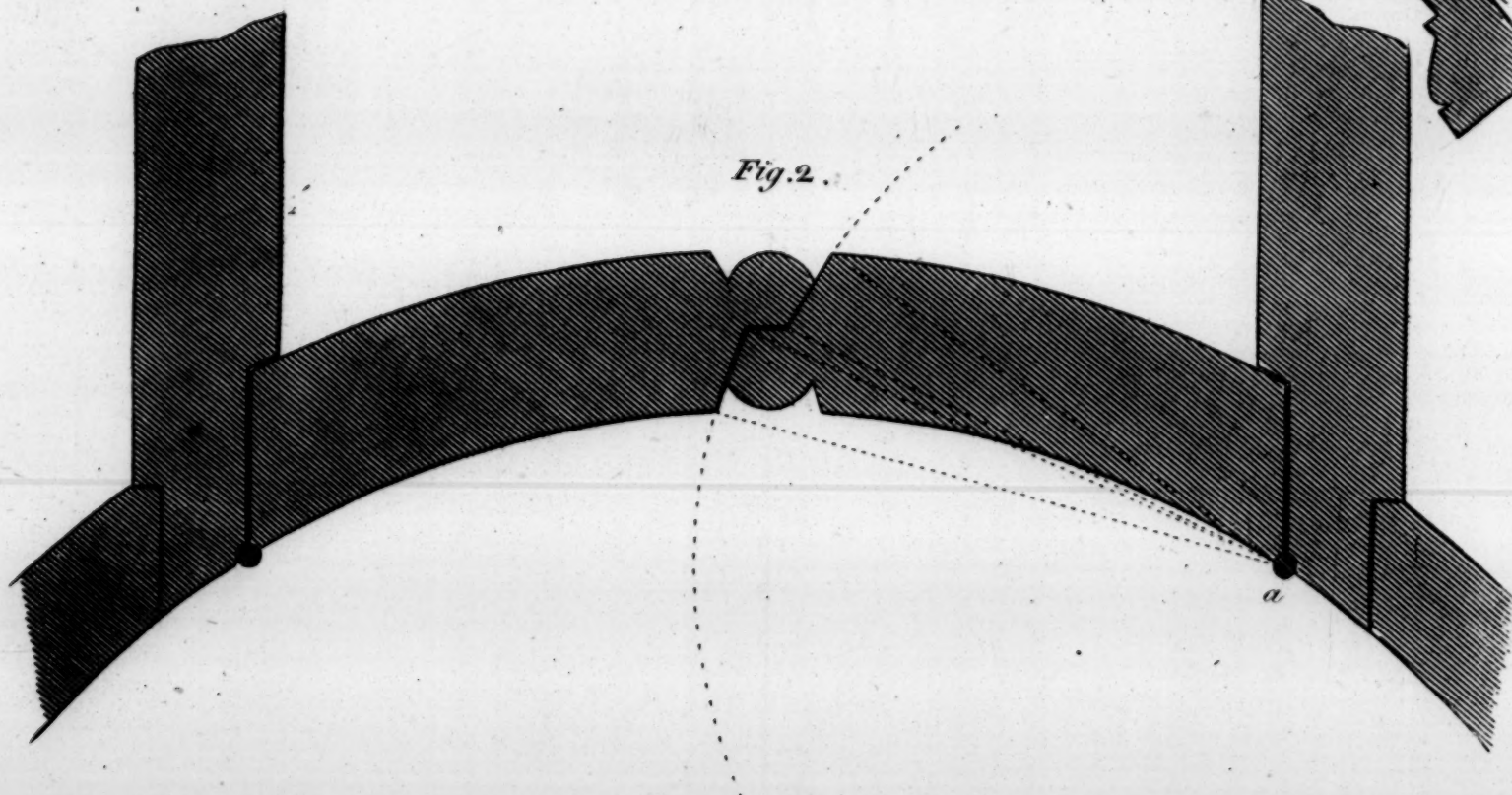
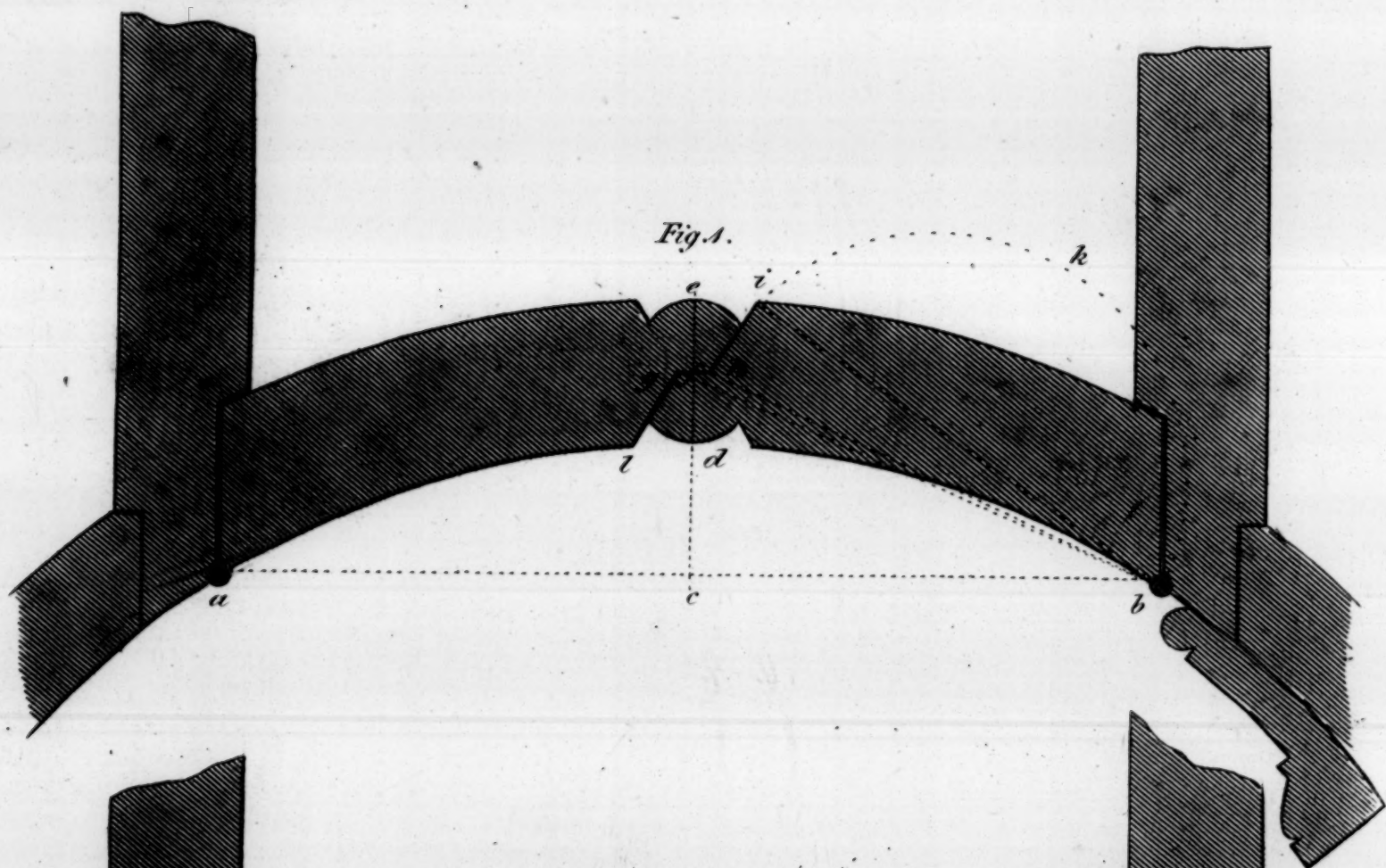


Fig. 2.









the door in d and e ; bisect $d e$ by a perpendicular $g f h$ at f ; make $f h$ and $f g$ each equal to half the thickness of the rabbet; join $h b$; on it describe the semicircle $h i k b$, cutting the other side of the door contrary to the knuckle of the hinge at i ; join $i h$ through g ; draw $g l$ parallel to it; then will $l g h i$ be the proper joint for the meeting of the two doors.

 PLATE XXXVII.

OF DOORS.

How to find the meeting joint of folding doors when the hinges are placed on the concave side of the door.

FIG. 1. Let a and b be the centres of the hinges; join $a b$ and bisect it by a perpendicular $c d e$ at c , cutting the thickness of the door at d and e ; bisect $d e$ by a perpendicular $g f h$, cutting $d e$ at f ; make $f h$ and $f g$ each equal to half the thickness of the rabbet; join $b h$; on it describe a semicircle $h i k b$, cutting the other side of the door contrary to the hinge at i ; join $i h$, and through g draw $g l$ parallel to it, cutting the concave side of the door at l ; then will $i h g l$ be the joint sought.

Demonstration.

Let the door $a l g h i$ remain in its place; now the angle $b i h$ being a right angle, consequently the perpendicular $b i$ will be the shortest line that can be drawn from the point b to the line $I H$; now let the half door be turned round the hinge at b ; the point i will then describe a circle whose centre is the hinge at b ; then will $i h$ be a tangent to that circle at i ; therefore the angle at i will touch no other part of $i h$, that is, the edge of the other door, but at i .

If round the centre of that door that opens, as *fig. 2*, you describe circles on each side of the rabbet, and the edges of each door be made circular, it is plain it will also open in this case.

PLATE XXXVIII.

OF DOORS.

Elevation and section of a pair of folding doors to open a communication between two rooms, or to make two rooms into one upon any occasion.

FIG. 1, the elevation of the folding doors.

a b c d, and *A B C D*, hanging styles hung to the jambs at *a b* and *A B*.

c d e f, and *C D e f*, the two doors hung to the hanging styles at *c d* and *C D*; the shadowed parts denote the hinges.

FIG. 2, the plan or rather a horizontal section.

The several parts of this door are shown at large in the next plate.

On one side of this plate the hanging style is pannelled, and on the other side it is reeded. The former will be proper when the hanging style is very wide, and the latter when it is very narrow.

PLATE XXXIX.

OF DOORS.

Horizontal sections of the foregoing plate, showing completely how the different parts of the work are connected with each other.

FIG. 1, a section of the jamb post.

B, b, sections of the grounds flush or in the same plane with the plaister.

E, e, outside and inside architraves.

g g g, line of the plinth.

C, jamb lining.

H, hanging style.

I, style hung to the hanging style *H*, by means of the hinge *m*.

FIG. 2, half of the plan, *fig. 1*, showing the door folded back; the parts in *fig. 2*, have the same references as *fig. 1*.

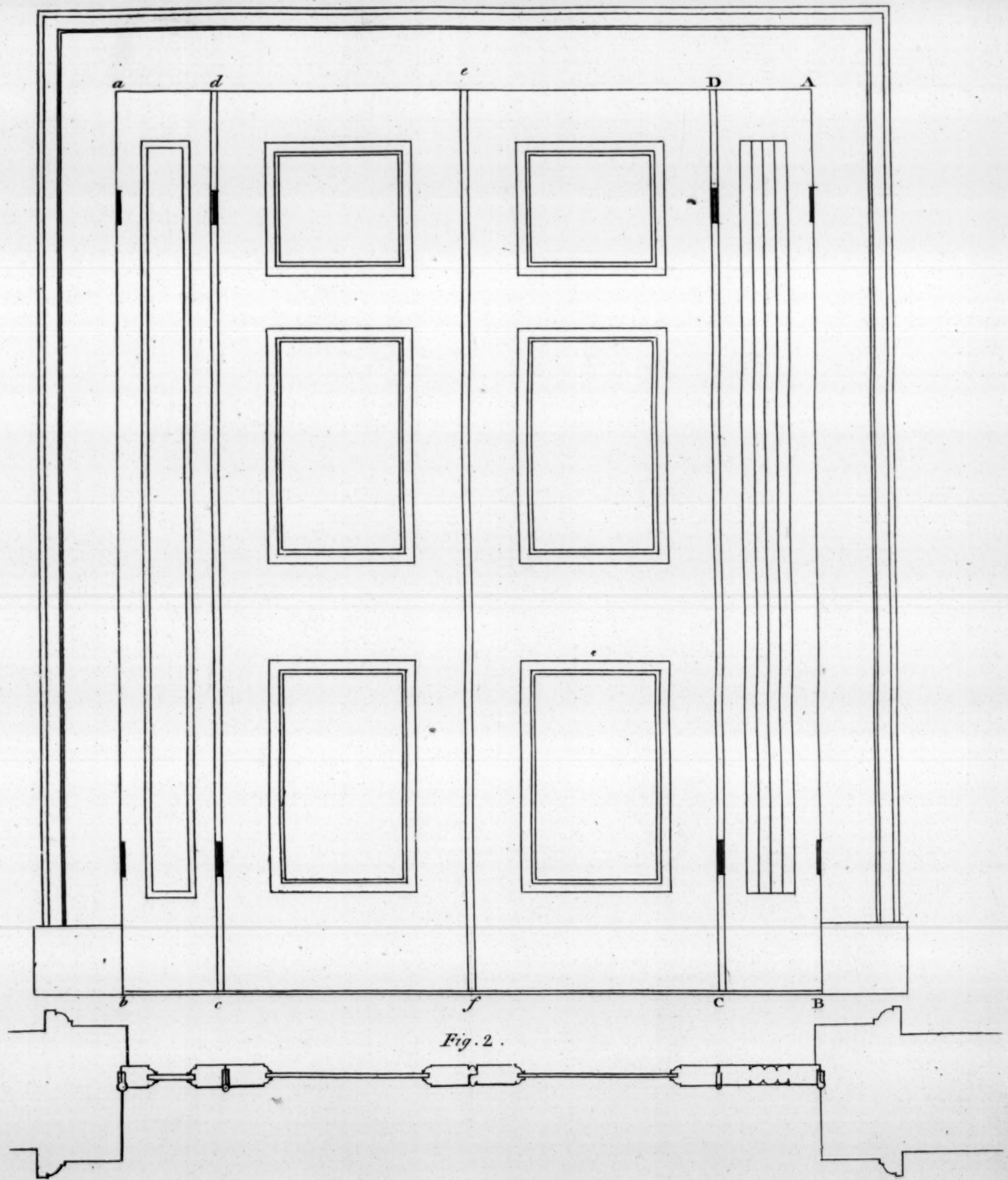
FIG. 3, the joint or hinge at *m* in *fig. 1*, with part of the style hinged together to a large size.

FIG. 4 and 5, shows how the joint must be made before hinged together.

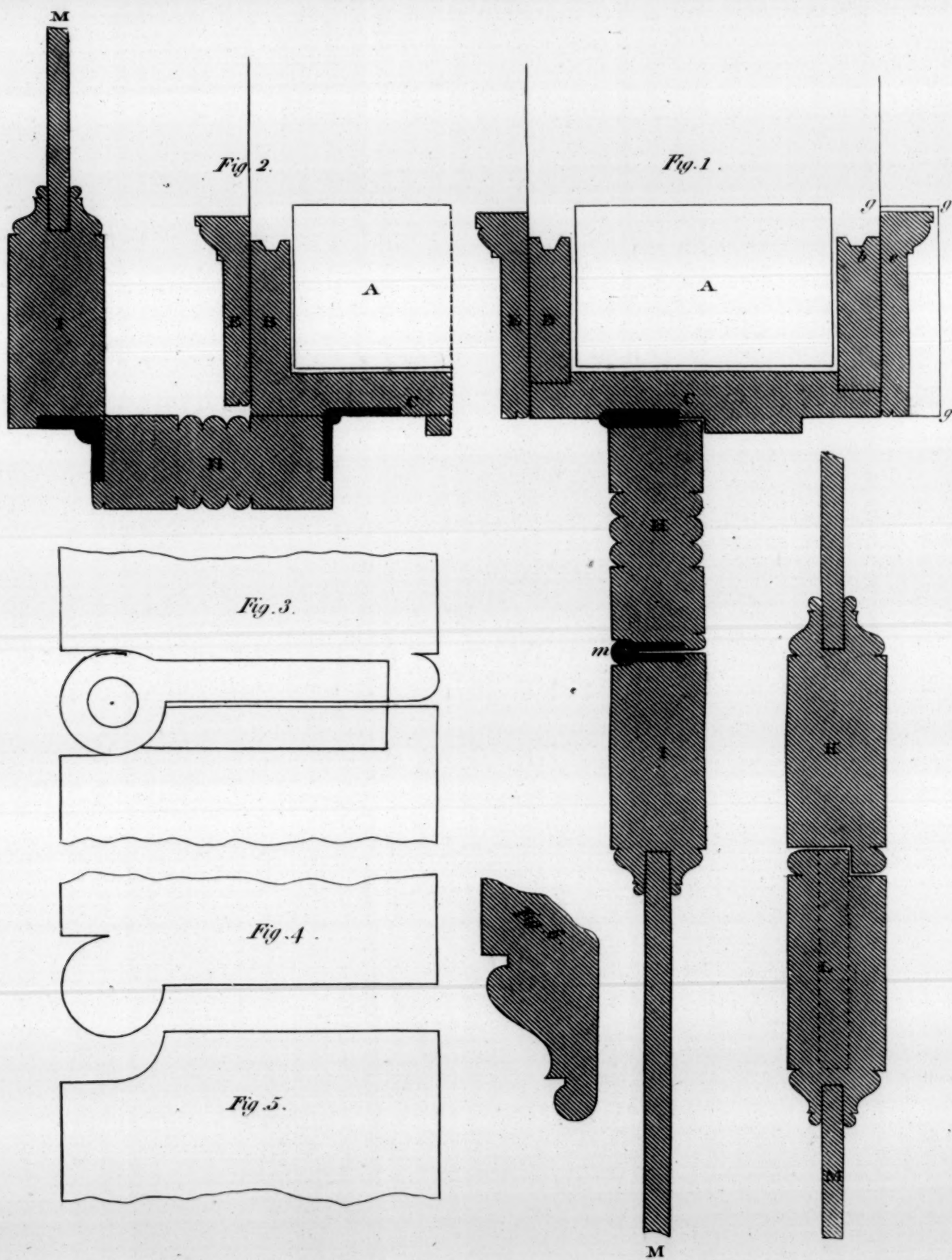
FIG.

Doors.
Fig. 1.

Pl. 38.











Doors.

Pl. 40.

Fig. 1

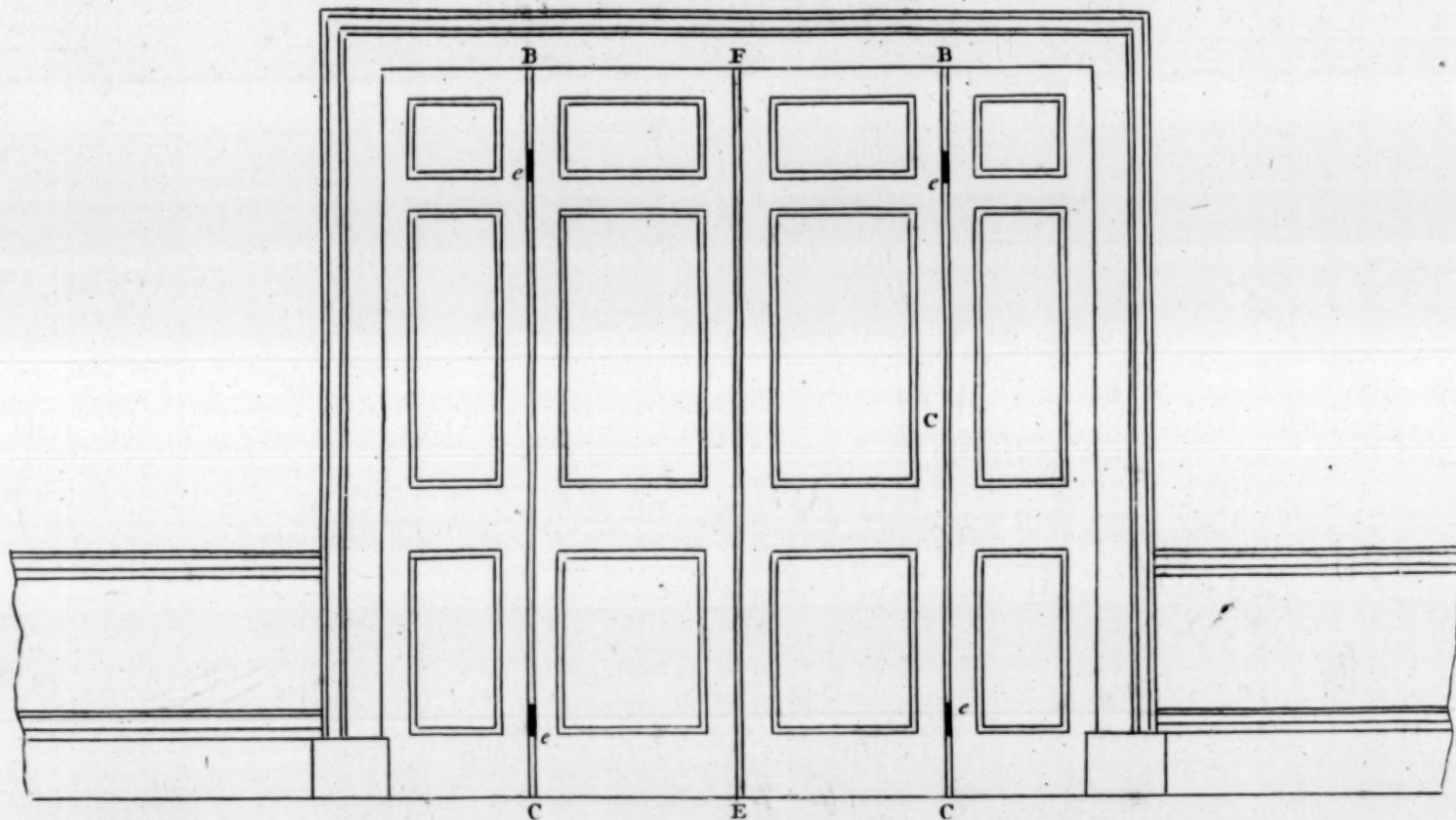


Fig. 2



Fig. 3

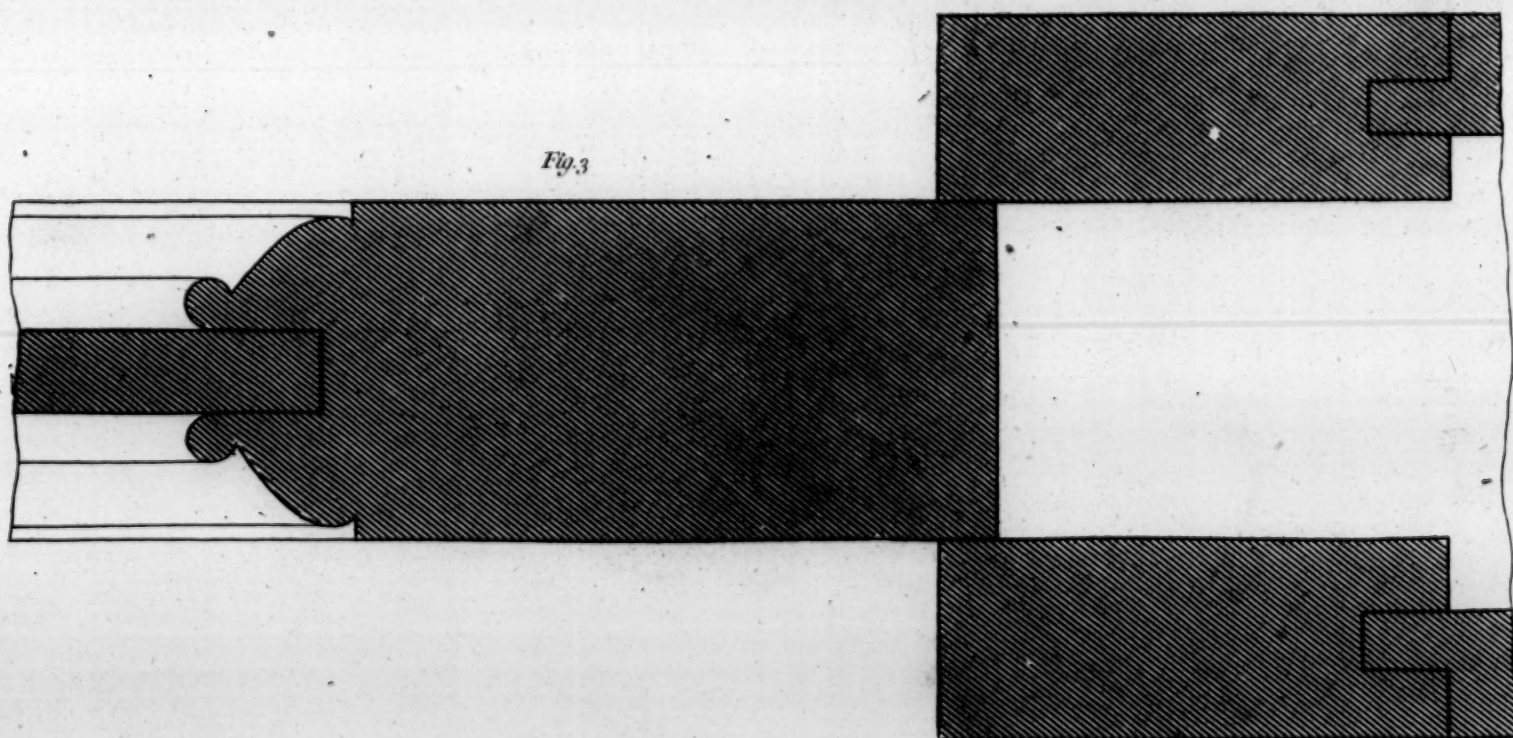


FIG. 6, the moulding of the door shown to a larger size.

This method is advisable where you have no opportunity of making the doors slide into the partition, as is shown in plate 40; but whenever that opportunity offers I should prefer it, as no door can be seen when shut into the partition, which not only keeps them entirely out of the way, but makes the most complete appearance.

PLATE XL.

OF DOORS.

Elevation of a pair of folding doors to be shut quite out of the way, in order to open a communication between two rooms, or to throw both into one on any occasion.

FIG. 1, elevation of the door.

FIG. 2, plan of half the door to double the size of fig. 1.

A, plan of the outside stile.

B and C, plans of the hanging styles.

D, one of the meeting styles.

G G G, and g g g, framed partitions distant from each other, in the clear, the thickness of the door.

F F F, the space or cavity for the door to work in, which must be made sufficiently wide to receive one half the door entirely within, or nearly so; doors of communication for general uses may be constructed in this larger door, in which case the middle pannels or doors may be hung to the others, at *e, e, e, e*, so that they will open like any other common folding door; this method therefore combines utility and convenience, and is a complete deception. The first leaf of the door, *A B*, fig. 2, must run in a groove at the top to make it steady.

The manner of making and hanging the joints *B C*, fig. 1, are already shown in plate 32, fig. 2, No. 1.

FIG. 3, a section of the stile next to the partition to a larger size, with part of the plan of the bottom rail, showing a small part of each partition.

Note.—In setting out work of this kind for practice, one half of the plan ought to be completely drawn out.

PLATE XLI.

OF DOORS.

The elevation of a Fib door; that is, a door which has the same finishings and appearance as the room in which it is placed, so that it may be known to be a door as little as possible.

FIG. 1, the elevation of the door, shewing the base and furbase mouldings of the other parts of the room. The top part of the door may be flush framing, which will be covered with paper as the other parts of the room. The bottom part, as in general, lined with half-inch stuff, running in the same direction as the dado, in order to show a continuation of the dado; afterwards the base and furbase moulding are fixed.

FIG. 2, the plan of the door.

A, the thickness of the base moulding.

B, the thickness of the lining.

C, the thickness of the pannel.

D, the lock stile.

E, the mountain.

F, the hanging stile.

FIG. 3, the furbase moulding to a larger size.

FIG. 4, the base moulding to a larger size.

The manner of hanging a door of this construction will be shewn in the following plates.

PLATE XLII.

OF DOORS.

The manner of constructing the base moulding of a Fib door by a circular motion in the joint.

FIG. 1, the elevation of the moulding.

FIG. 2, section of the door and jamb.

From A, the centre of the hinge, draw AB perpendicular to the face of the door; make AB equal to the projection of the furbase moulding in fig. 1. Make all the projections Ag,

Doors.

Pl. 41.

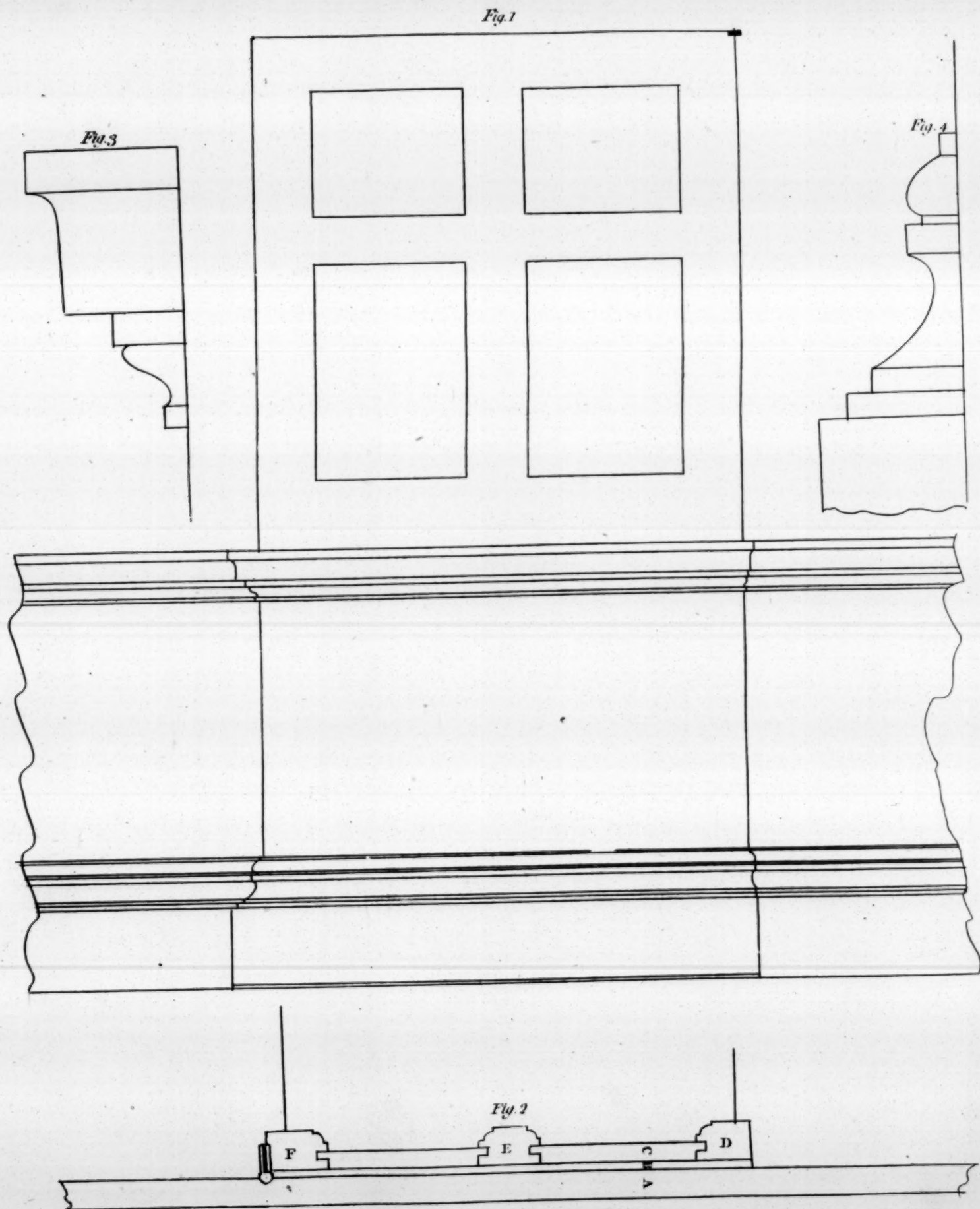




Fig. 1.

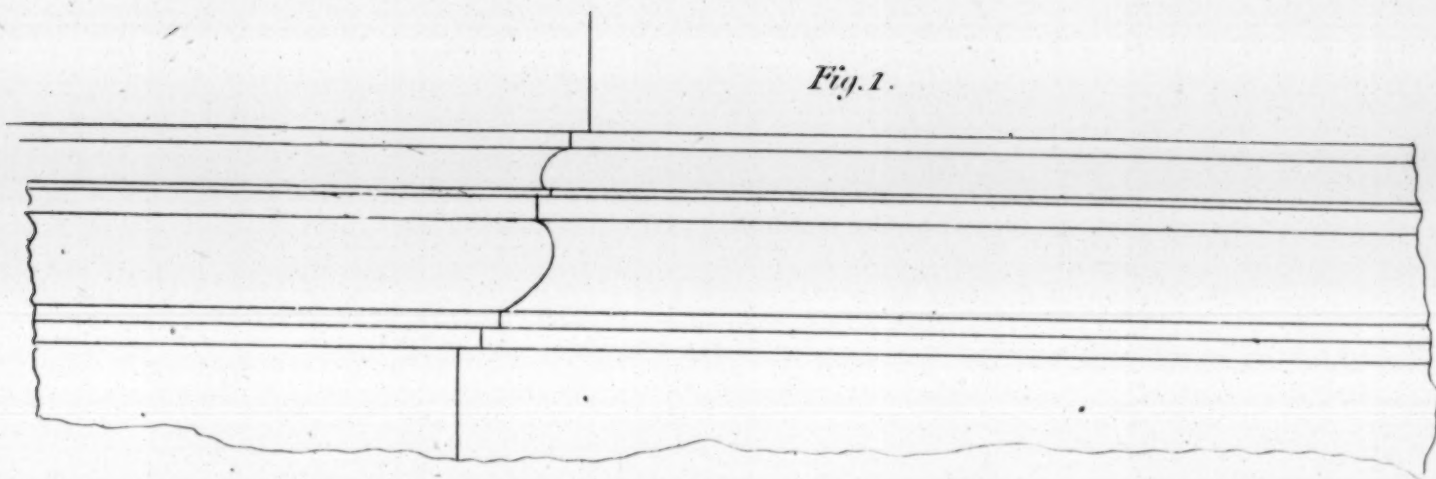


Fig. 2.

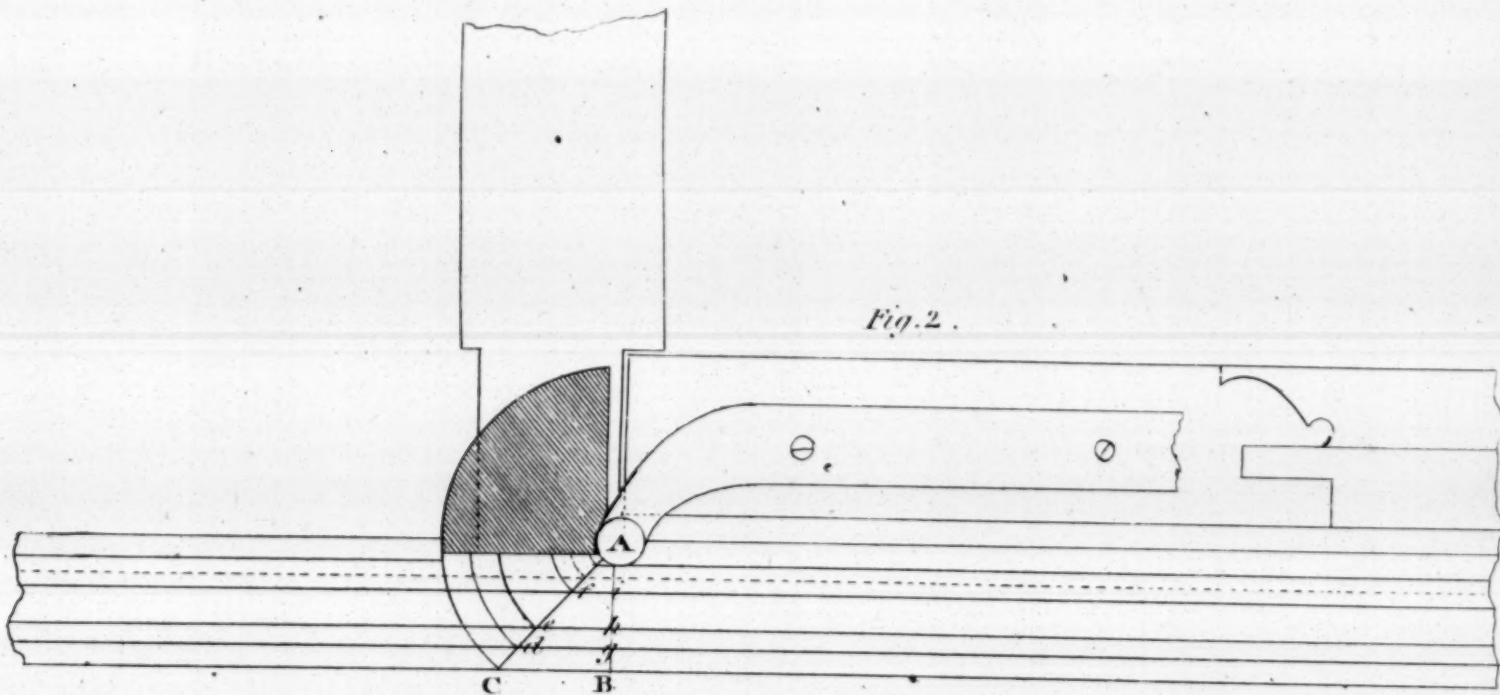
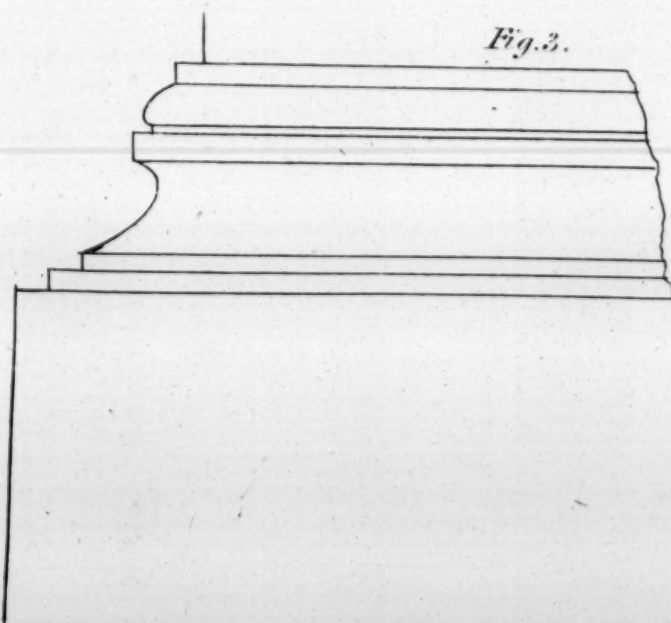
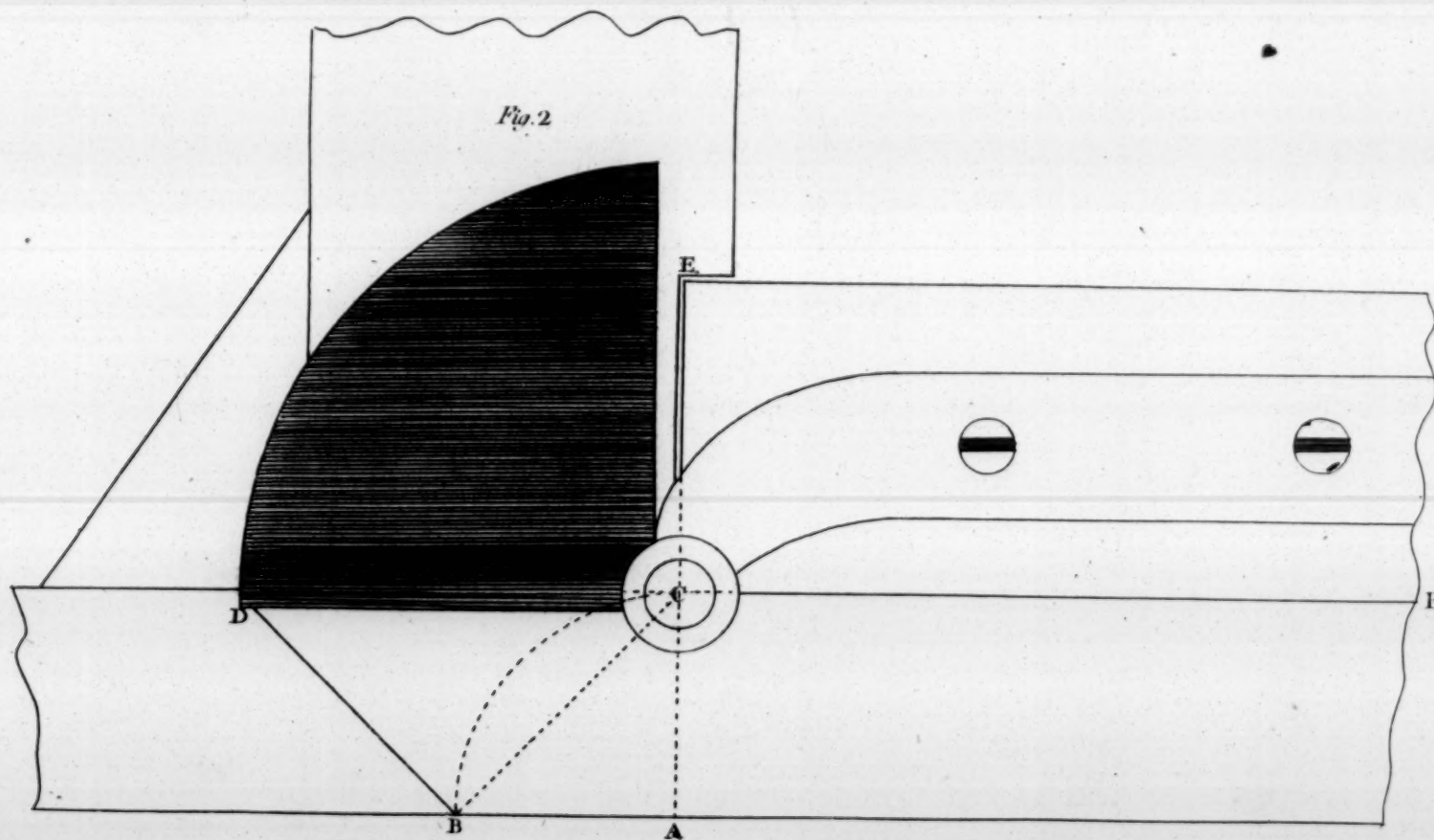
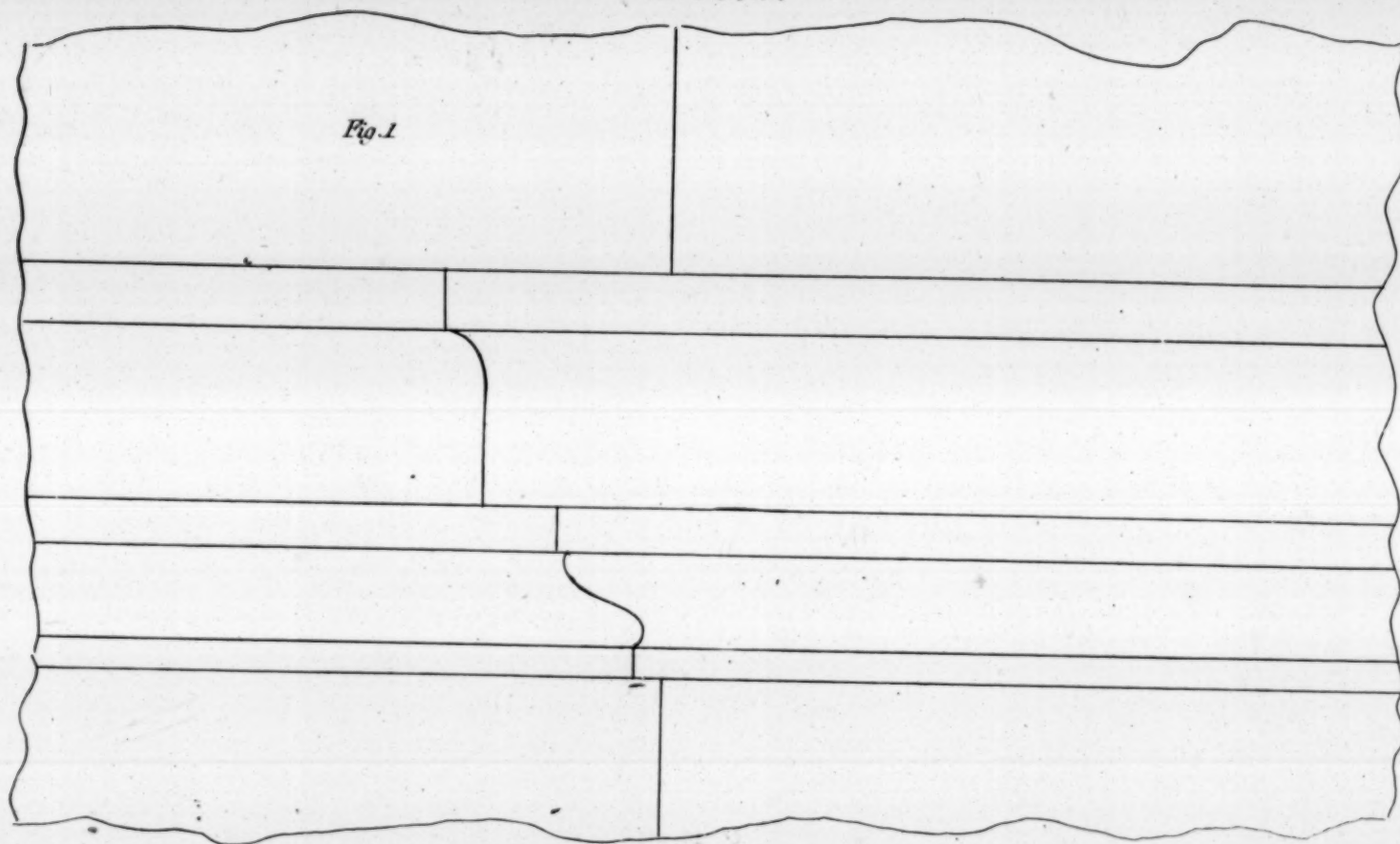


Fig. 3.









Ag , Ab , and Ai , equal to all the projections of the fillets in *fig. 1*; through the points B , g , b , i , draw parallel lines; make BC equal to the projection AB , and join AC cutting the parallel lines at d , e , f ; then from the centre A with the radii Ad , Ae , and Af , describe arcs dk , el , and fm , for the joint of each fillet, and the jamb must be cut out to fit these joints; but there must be about one-sixteenth part of an inch left whole on that edge next to the door; and since the door describes one quarter of a circle, there must also be one-sixteenth part of an inch cut out of the base moulding; this will appear a small defect when the door is shut, because it will appear open where it is cut away in the surbase; but not being more than one-sixteenth part of an inch, will nearly be covered by the paper.

FIG. 3, shows the projections of the mouldings along the diagonal Ac , which is to be applied on the back of the surbase moulding, in order to be a guide to work it out circular on the back.

PLATE XLIII.

OF DOORS.

How to find the joint of a Fib door, so that it shall open freely at the hanging side, and the joint to be a plane.

FIG. 2. Let C , the centre of the hinge, be in the same plane with the dado, and also with the joint CE .

CE , the thickness of the door at the joint, which produce till it cut the opposite side of the base moulding at A ; make AB equal to AC ; join BC , and from B draw BD perpendicular to BC ; then will BD be the true line on which the surbase moulding must be cut perpendicular to the floor. The shadowed part shows a part of the jamb lining cut out sufficient to let the surbase moulding move in it.

Note.—The jamb lining must not be cut quite through, but there must be a small substance of wood remaining, otherwise the whole cavity of the door will show when it is open.

Also remember to put a blocking in the interior angle opposite to the hollow part, which is cut out in order to let the surbase moulding move in it, if the thickness of the jamb lining is not sufficient.

The bottom part of the door may revolve on a centre or pivot in the floor, by this means the centre will be quite concealed.

The upper part may be hung with butt hinges, and the centre of the hinge must be in the same plane with the face of the door, so the joint upon the hanging side will always be close.

FIG. 1, the elevation of the joint.

PLATE

PLATE XLIV.

OF DOORS.

How to hang folding doors so that each door shall open or shut together, called Sympathetic Doors.

FIG. 1, the lower part of the folding doors, showing two cranks under the floor; cc shows the centres of the cranks; the two cranks are connected together by means of a rod AA .

FIG. 2, the plan of the cranks; cc their centres; AA the rod fixed to each crank as in the elevation, fig. 1.

How to find the position of the cranks so that they shall have the most effect to open or shut the door.

FIG. 2. Join cc the centres of the hinge, make the angles ccA , and ccB , each half a right angle; then complete the quadrants AB , and AB ; then will AB be the distance that each crank ought to move, so as to make each door open to a right angle, and which will open with the greatest ease.

FIG. 3, shows the elevation of a crank to a larger scale, D is the side of a strap made on the crank, in fig. 4, shows the plan of the same. This strap is screwed to the under side of the door, in order to keep the crank firm.

E , in fig. 3, shows part of the edge of another strap made to the crank, which is screwed to the edge of the door upwards; this does not show in the plan fig. 4. These two straps will perfectly secure the cranks and keep them firm.

PLATE XLV.

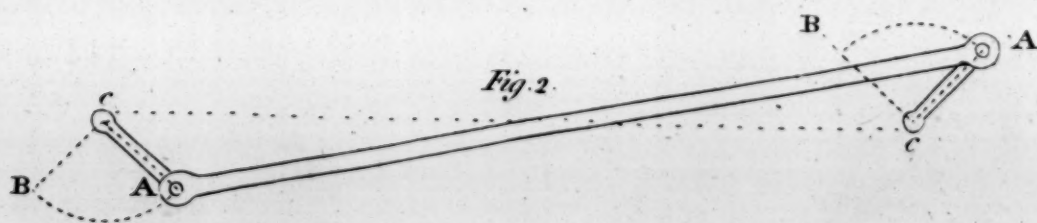
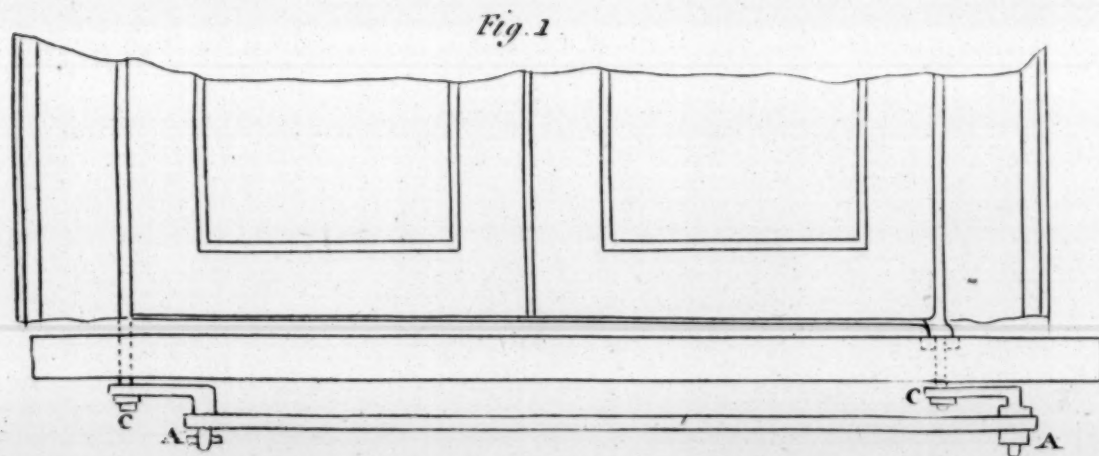
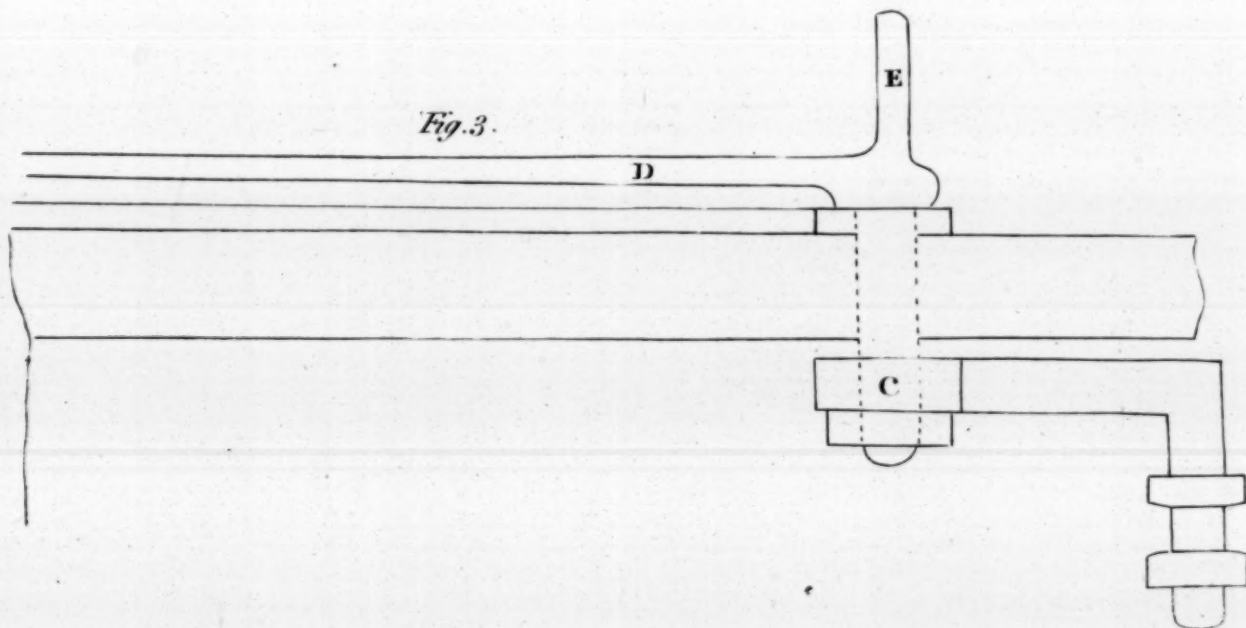
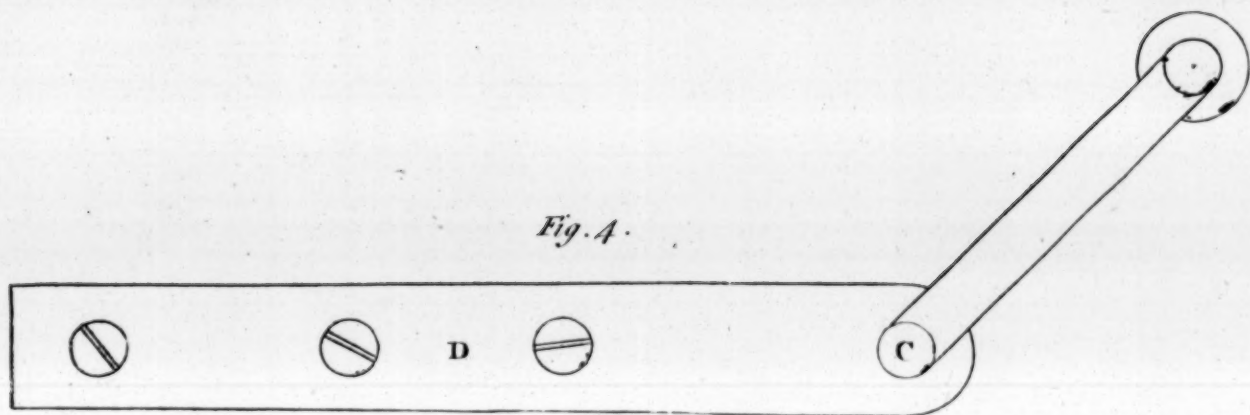
A SASH FRAME.

The construction of a sash frame, and the manner of putting the several parts of it together.

FIG. 1, the elevation of the sash frame.

$ABCD$, the outer edge of it.

The dark perpendicular lines EF , GH , are grooves whose distances are from the edges of the sash frame LM , and KI , equal to the depth of the boxing, together with three-eighths





Sash Frame.

Pl. 45.

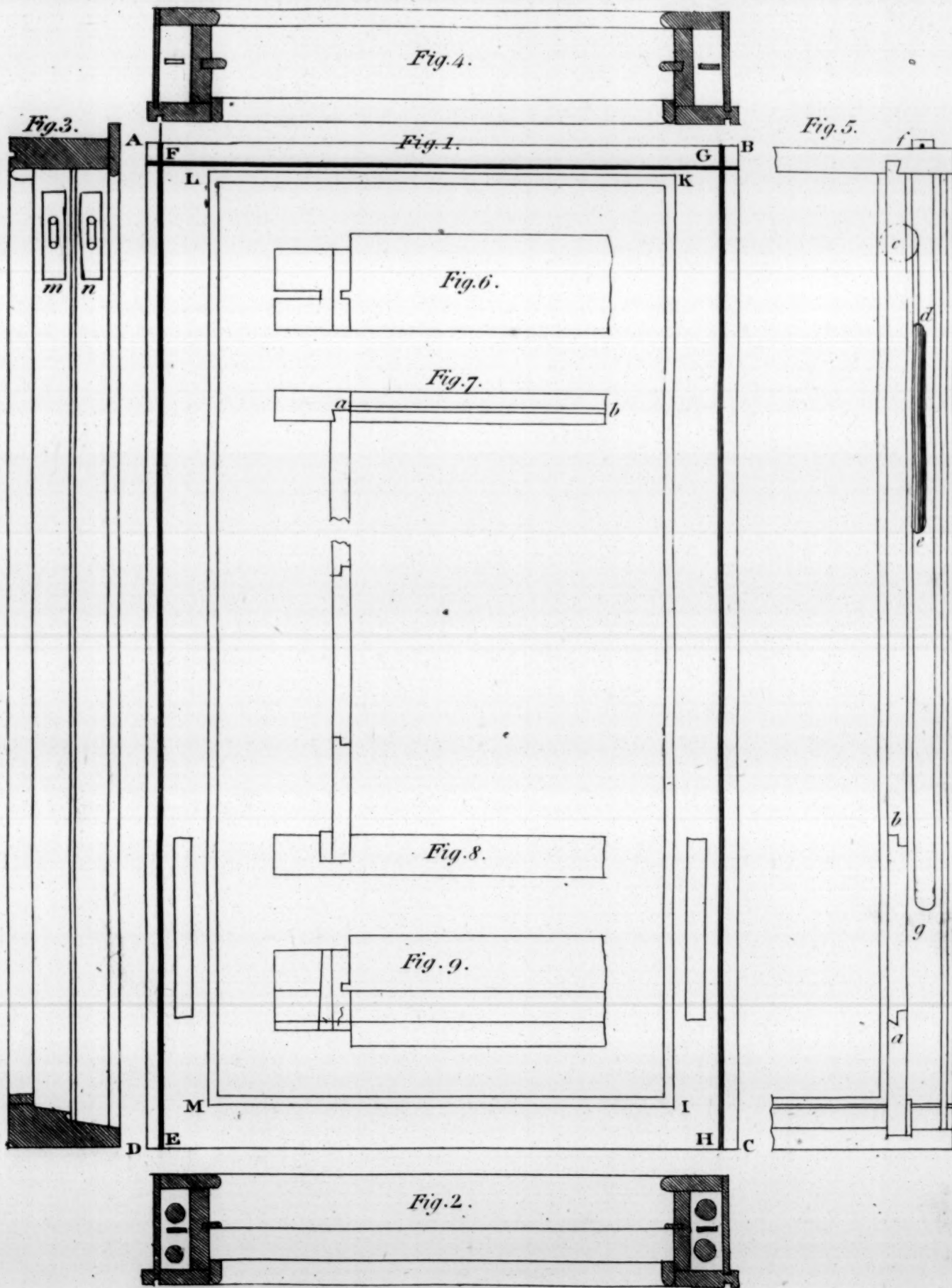






Fig. 1.

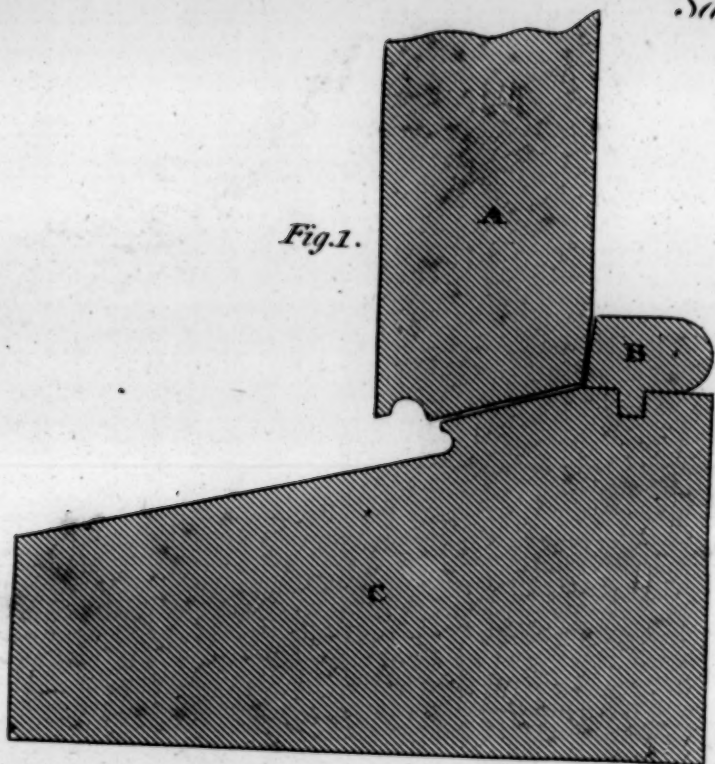


Fig. 2.

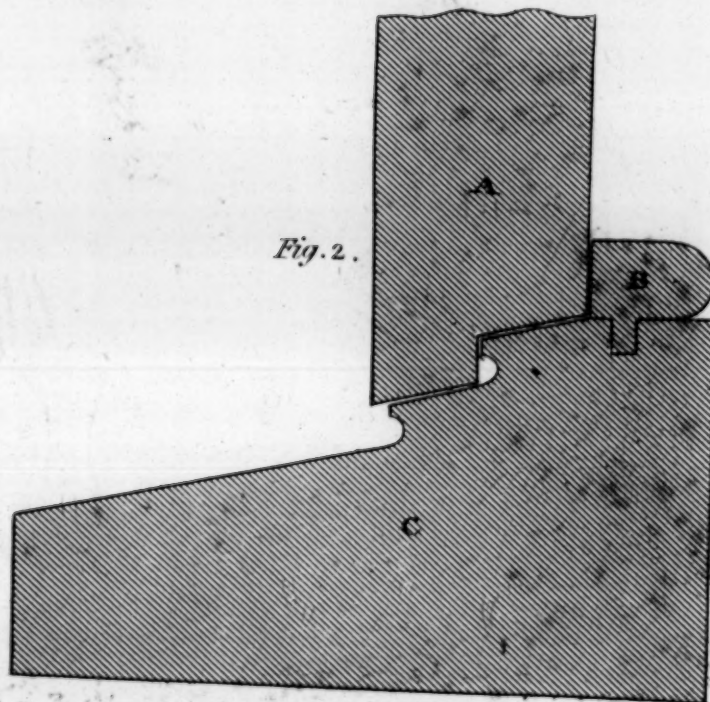


Fig. 3.

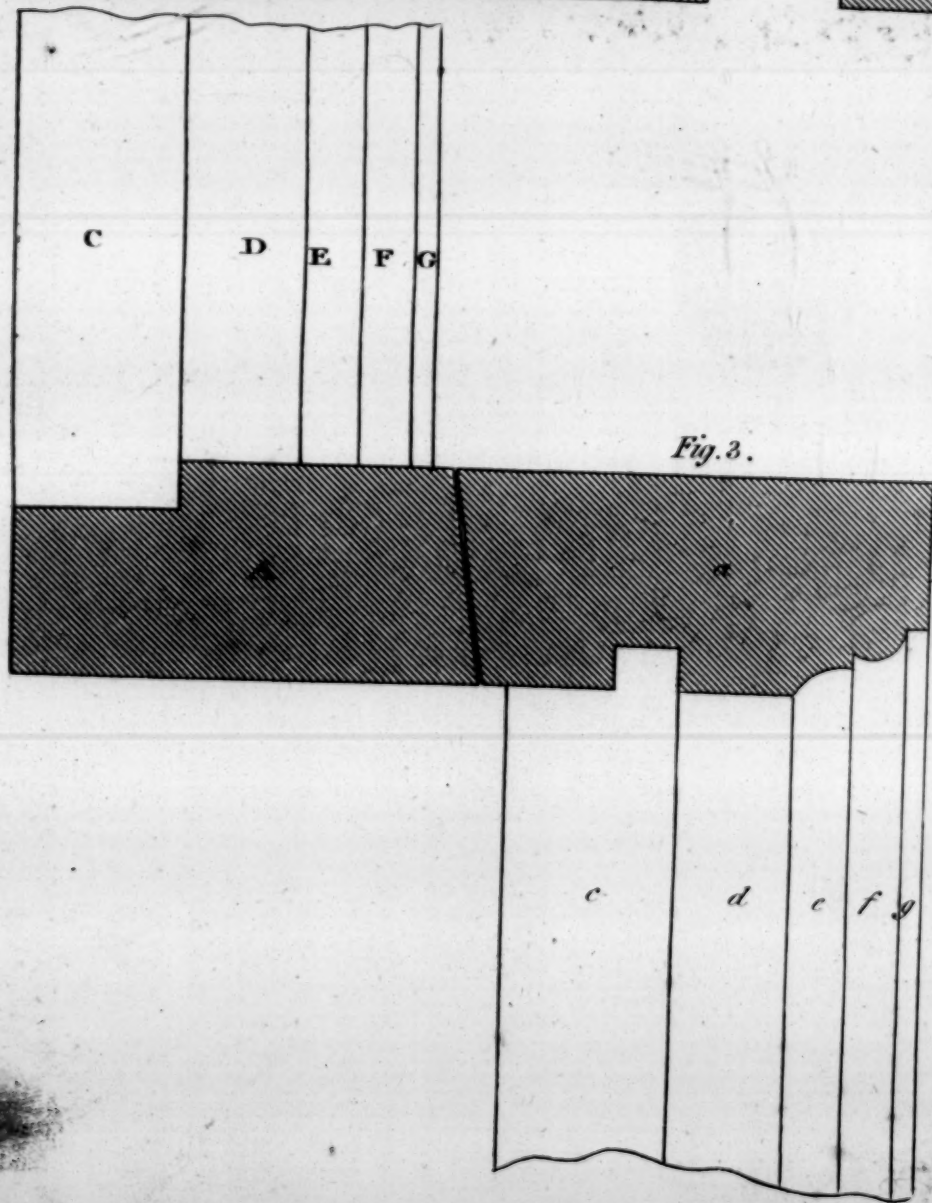
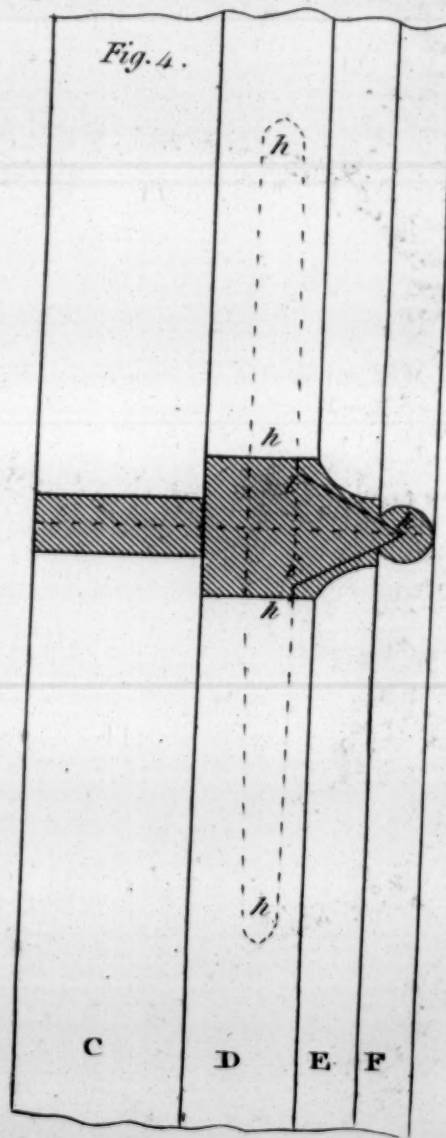


Fig. 4.



three-eighths of an inch more that is allowed for margin between the face of the shutter, when in the boxing, and the edges *ML*, and *KI*, of the sash frame next to the bead.

FIG. 2, horizontal section of the sides, showing also the plan of the fill.

FIG. 3, a vertical section of the fill and top, showing the elevation of the pulley style *m* and *n*; the pulleys let into the pulley piece.

FIG. 4, the horizontal section of the sides, showing also a plan of the head of the sash frame.

FIG. 5, the elevation of the outer side of the sash frame: the outside lining being taken away in order to show the work within the sash frame.

f g, the parting strip fastened by a pin; *ed*, one of the weights connected to the sash by means of a line going over the pulley *c*; the other end fixed to the edge of the sash.

Note.—The weight *ed* is equal to half the weight of the sash.

FIG. 6, the head of the sash frame before put together.

FIG. 7, the edge of fig. 6.

FIG. 8, the edge of the bottom, showing the manner of putting the styles into it.

FIG. 9, the plan of fig. 8.

PLATE XLVI.

SASH SILLS AND SASHES.

FIG. 1 and 2, sections of window sills, with sections of the under rail of the sash, showing the best modes of constructing them in order to prevent the weather from driving under the sash rail.

A, section of the bottom rail of the sash.

B, section of the bead tongued into the fill.

C, section of the fill.

FIG. 3, sections of the meeting rails, with the side elevations of the upright bars.

C, rabbet for the glass.

D, a square.

E and *F*, an astragal moulding.

G, fillet.

Note.—The small letters denote the same parts of the under sash.

FIG. 4, section of an upright bar, with the plans of two horizontal bars, showing the manner in which they are put together so as to keep the upright bars as strong as possible.

F

The

The thickness of the tenon in general comes about one-sixteenth of an inch to the edge of the hollow of the astragal, and close to the rabbet on the other side.

h h a dowel to keep the horizontal bars still firmer together.

Note.—The same parts in this have the letters of reference the same as *fig. 3*.

Note also, there is no rabbet made for the glass on the inside meeting rail; a groove is made to answer that purpose.

PLATE XLVII.

SHUTTERS.

Section of common shutters and sash frame.

FIG. 1, A, section of the architrave of windows.

B, ground for the architrave.

F, back lining of the boxing, tongued into the ground *B*, and into the inside lining *G*, of the sash frame.

G, the inside lining of the sash frame.

H, the inside bead.

I, the pulley piece.

K, the parting bead,

L, outside lining.

M, back lining.

CCC, the front shutter hung to the inside lining of the sash frame *G* by means of the hinge *a*.

DDD, back flap or shutter hung to the front shutter by means of the hinge *b*.

EEE, another back flap hung to *DDD*, by means of the hinge *c*.

As in a window the whole of the light should be shut out, the principle of setting out the shutters is, that each boxing should contain as many shutters as will cover one half, that is from the centre of the hinge to the centre of the window.

PQR, plan of the lower sash.

P, the rabbet for the glass.

Q, a square.

R, an astragal moulding.

R, a small square or fillet.

FIG. 2, the method of hingeing two back flaps together, showing the manner of placing the hinge, when room is scanty in the boxes.

PLATE

Fig. 1.

Fig. 2.

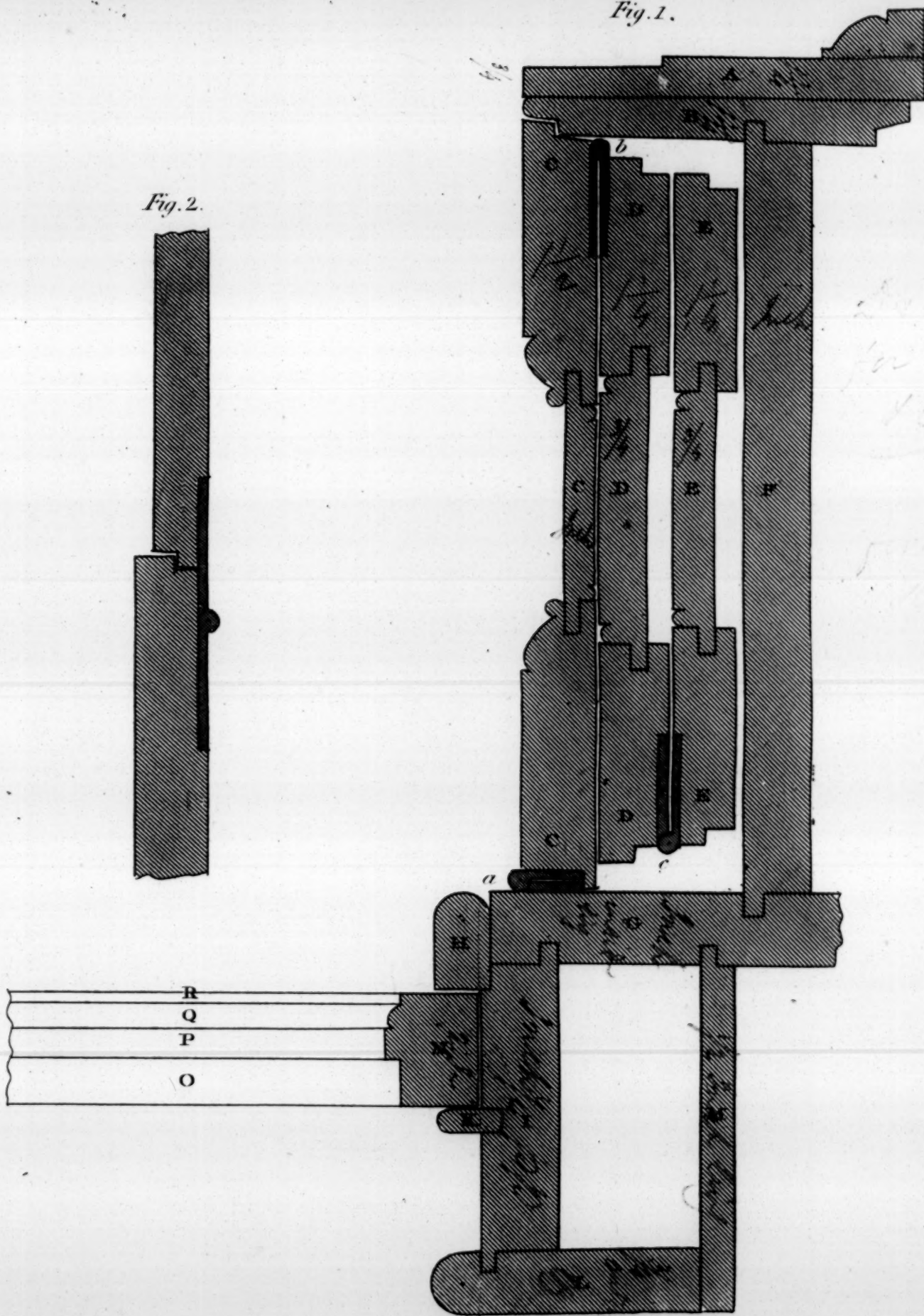






Fig. 2.

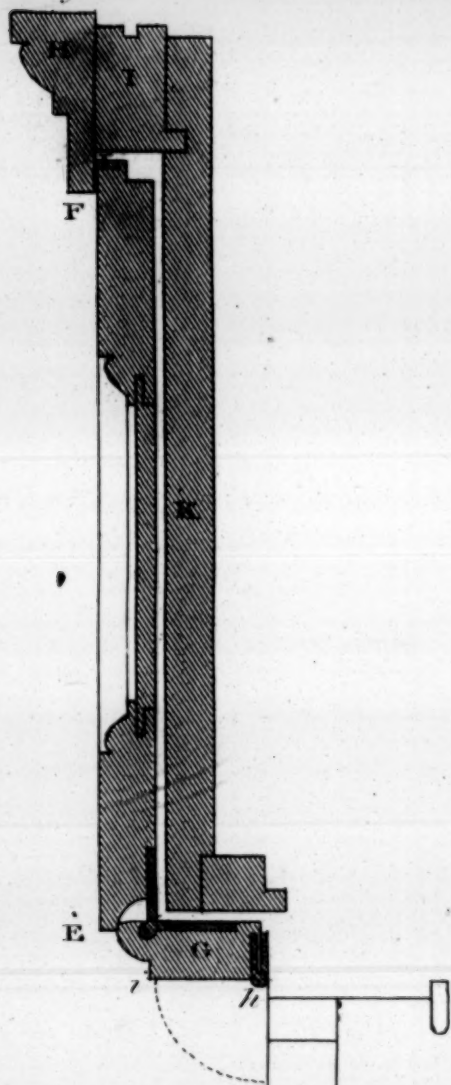
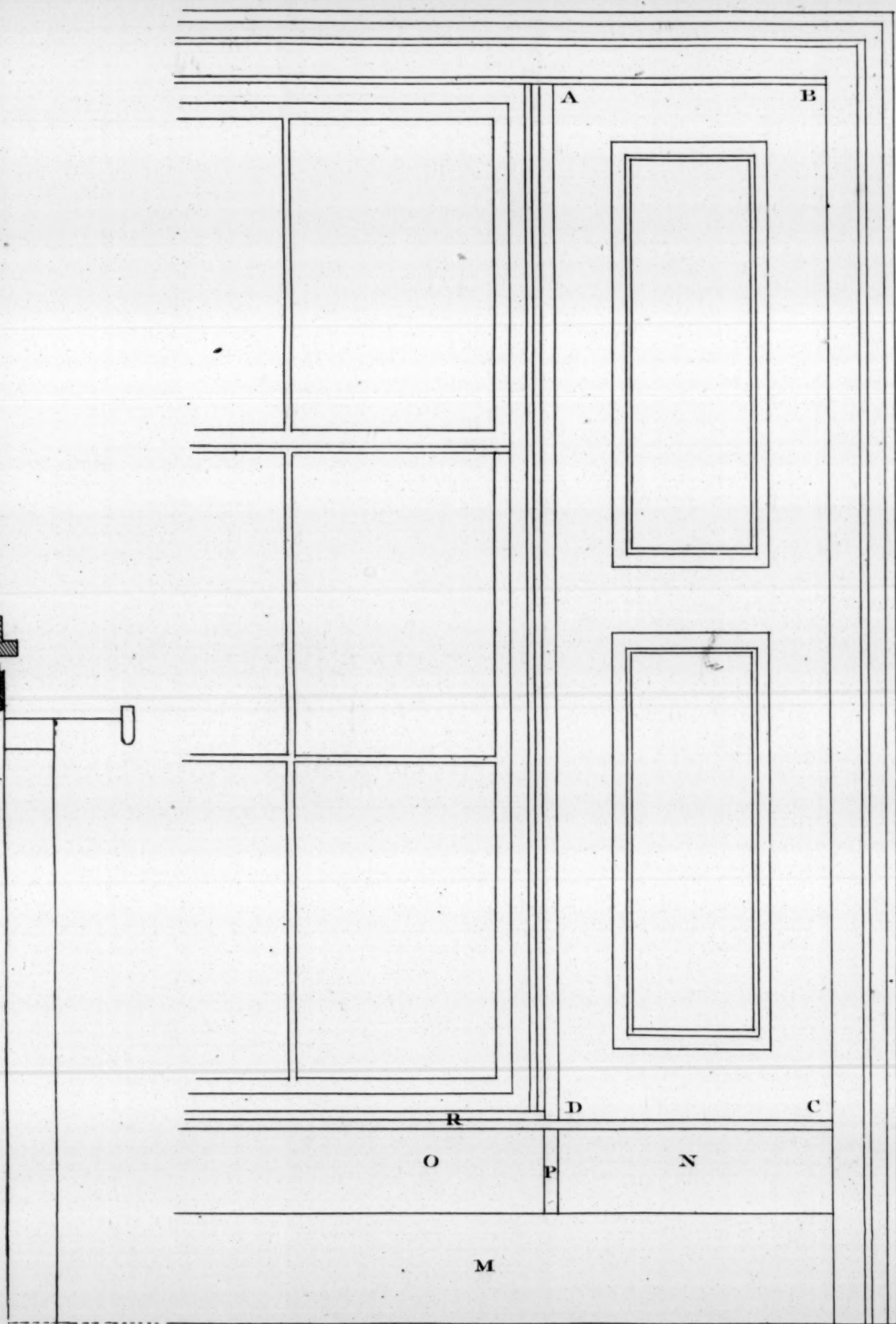


Fig. 1.





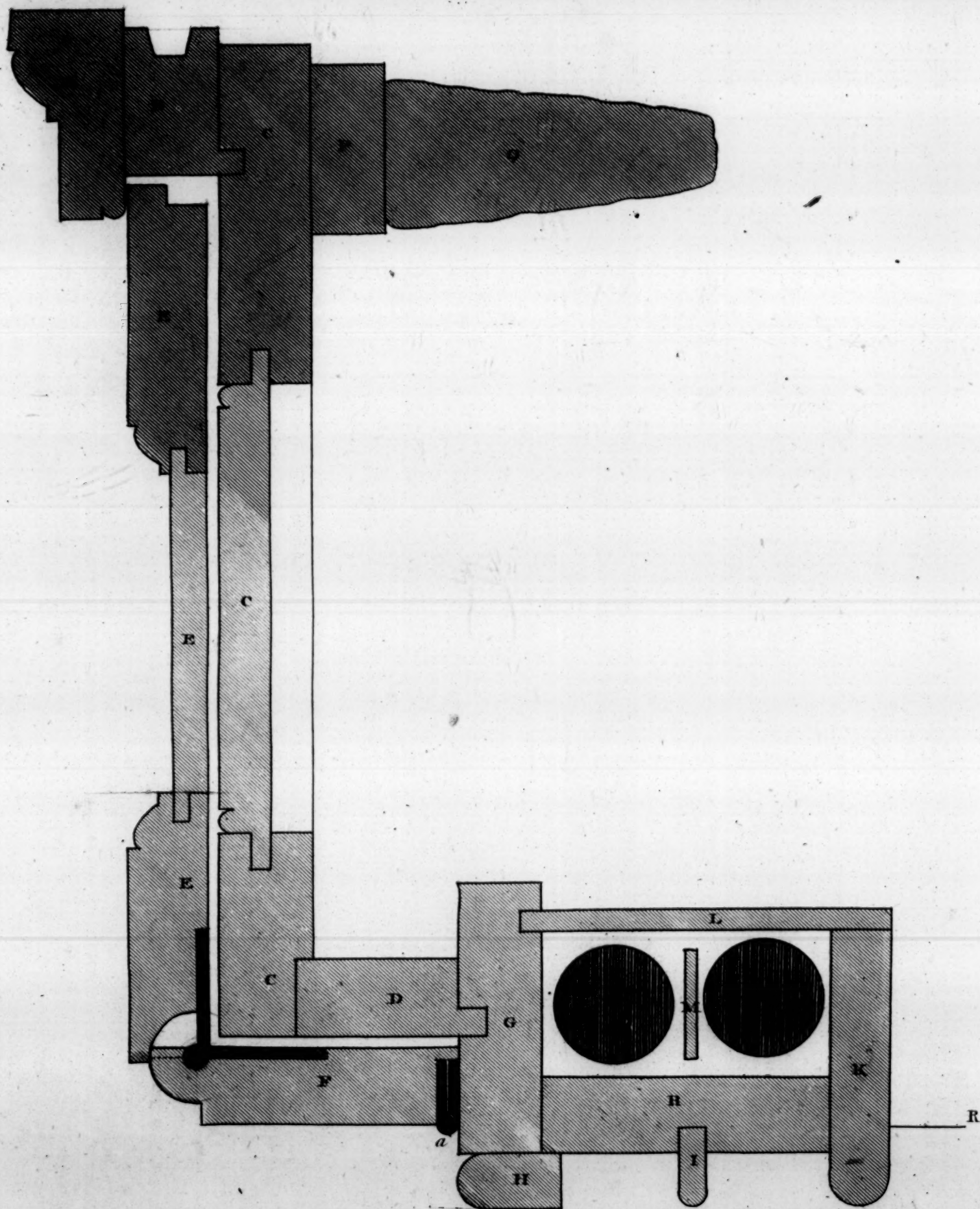


PLATE XLVII.

SHUTTERS.

Elevation and plan of half a window adapted for a staircase, when the wall of the building is not sufficiently thick to admit of room for boxing.

FIG. 1, elevation of half the window.

FIG. 2, plan of the window to double the size of the elevation in order that the parts may be more distinctly seen.

E F, the breadth of the shutter, which is hung to a hanging stile *G*, and the hanging stile *G* is hung to the sash frame by the hinge at *h*.

The whole breadth of the shutter *E L*, together with the breadth of the hanging stile at *G*, that is *i h*, ought to cover exactly half the breadth of the window, or half the rabbet at *L*, more than half the breadth of the window.

H, architrave; *I*, back ground; *K*, back lining.

The pannelled part *A B C D*, at fig. 1, represents the shutter of which *E F*, in fig. 2, is the breadth.

The hanging stile and shutter is hung together by means of a rule joint, as before described in plate 29.

Under the shutter *A B C D*, is a bead *R*, and continued across the sash frame to serve for a capping; *P* is a vertical bead continued in a line with the edge, at *D*, of the rule joint.

O and *N*, pieces of wainscoting coming flush with the bead *P*, *M* the skirting board.

PLATE XLIX.

SHUTTERS.

A section of the preceding window, to a larger scale.

A, architrave moulding.

B, ground.

C C C, back lining.

D, the lining, or the return of the window.

E E E, the shutter hung to the hanging stile *F*, which is hung to the sash frame by the hinge at *a*.

F 2

G, the

G, the inside lining of the sash frame.
H, inside bead.
I, parting bead.
K, outside bead.
L, back lining.
M, the parting slip for the weights *N* and *O*.
N and *O*, weights.
P, ground fixed upon the plug.
Q, the plug.
R, pulley piece.

 PLATE L.

SHUTTERS.

The plan, front, and side elevation, and section of a window proper for a building where the walls are not thick enough to admit of room for boxings, which will show the same finish as if there were boxes for the shutters.

FIG. 1, front elevation of the window.

The dotted lines *a b c d*, represent a piece of framing.

The other side, *A B C D*, represents a sliding shutter in the wall.

The framing is supposed to be removed in order to show the shutter.

FIG. 2, the side elevation and section, supposing the shutter removed.

a, an architrave moulding.

b, soffit.

c, top of the sash frame.

d, capping tongued into the sash frame fill.

FIG. 3, horizontal section and plan of the window, twice the size of the elevation.

g g, section of the framing as shown by *a b c d*, fig. 1, by dotted lines.

b b, plaistering on the wall.

i i, a shutter hung to the sash frame at *m*.

f f, section of the sliding shutter, which runs on rollers.

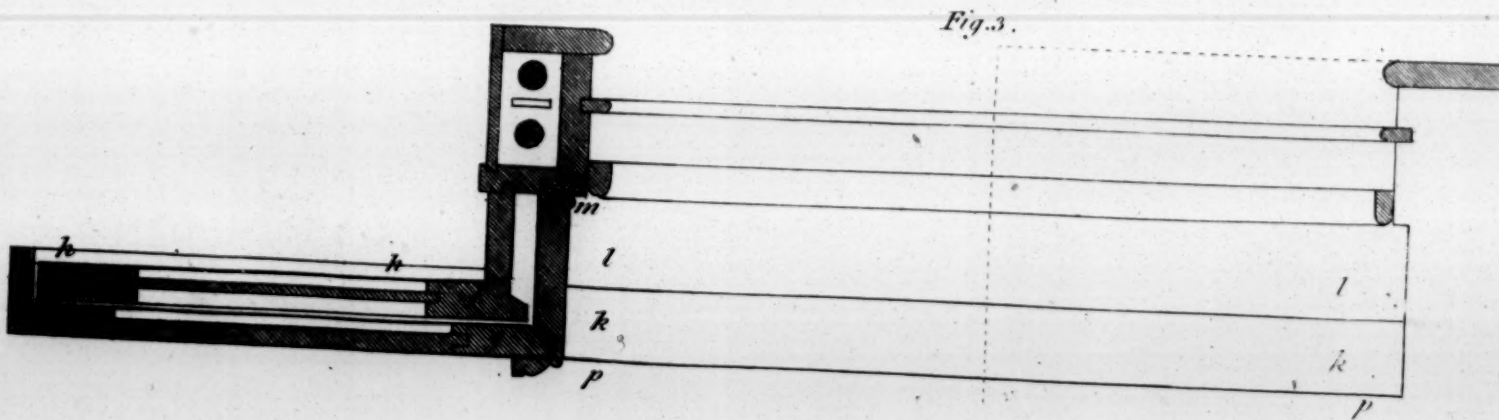
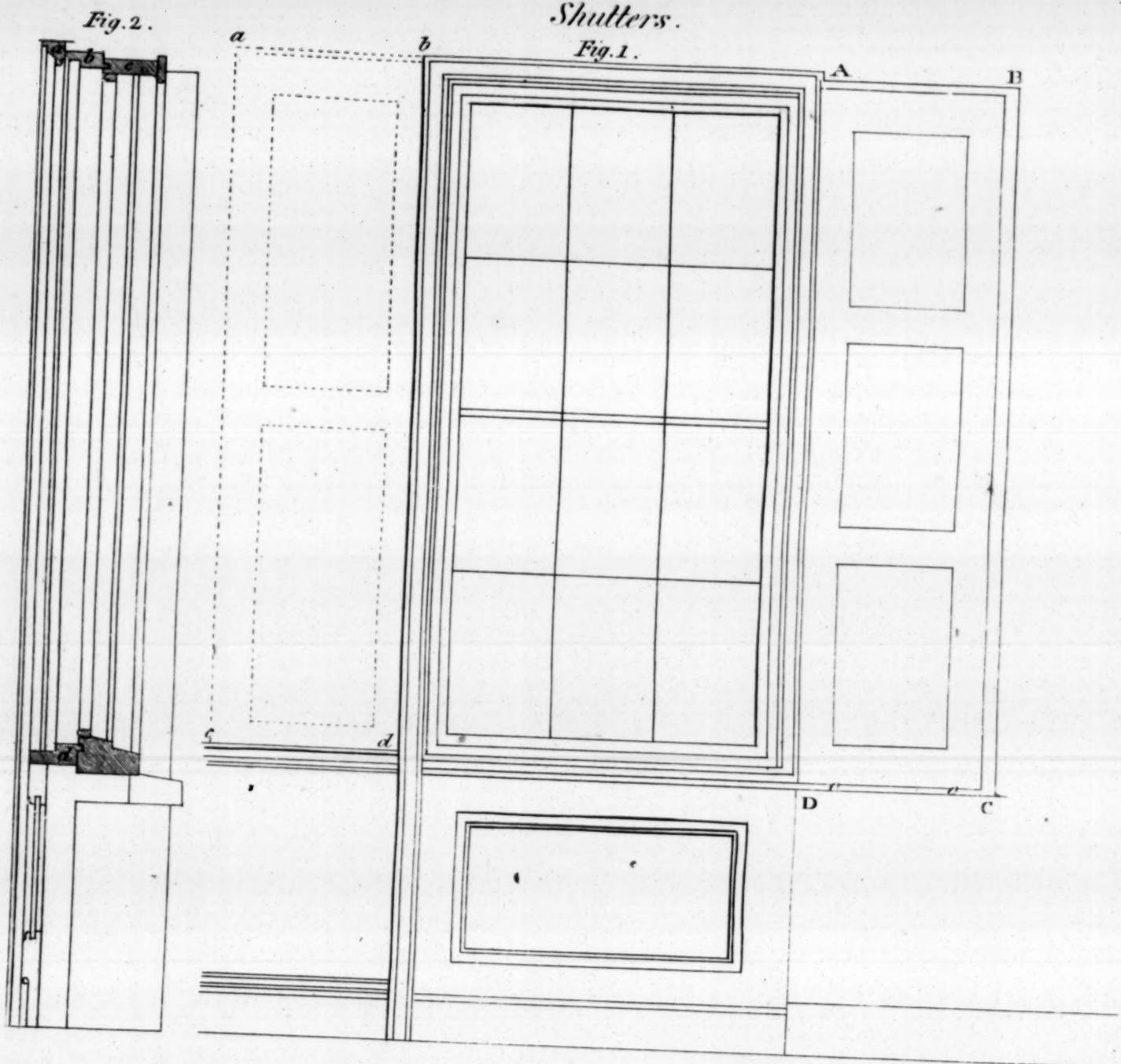
k k, a flap which is let into a rabbet and hinged at the edge *p p*, so that when the flap is turned round, the hinges out of the rabbet, and the shutter *i i* turned to the face of the window, there will be a clear passage for the shutter *f f* to run out.

Not.—Although there is only a stop for the back of the shutter at the bottom, yet it is quite sufficient as it is stopped on both sides at the top, and as the edge of the shutter should never be entirely out of the boxing.

This is more clearly shown by the parts drawn larger in the next plate.

PLATE

Shutters.







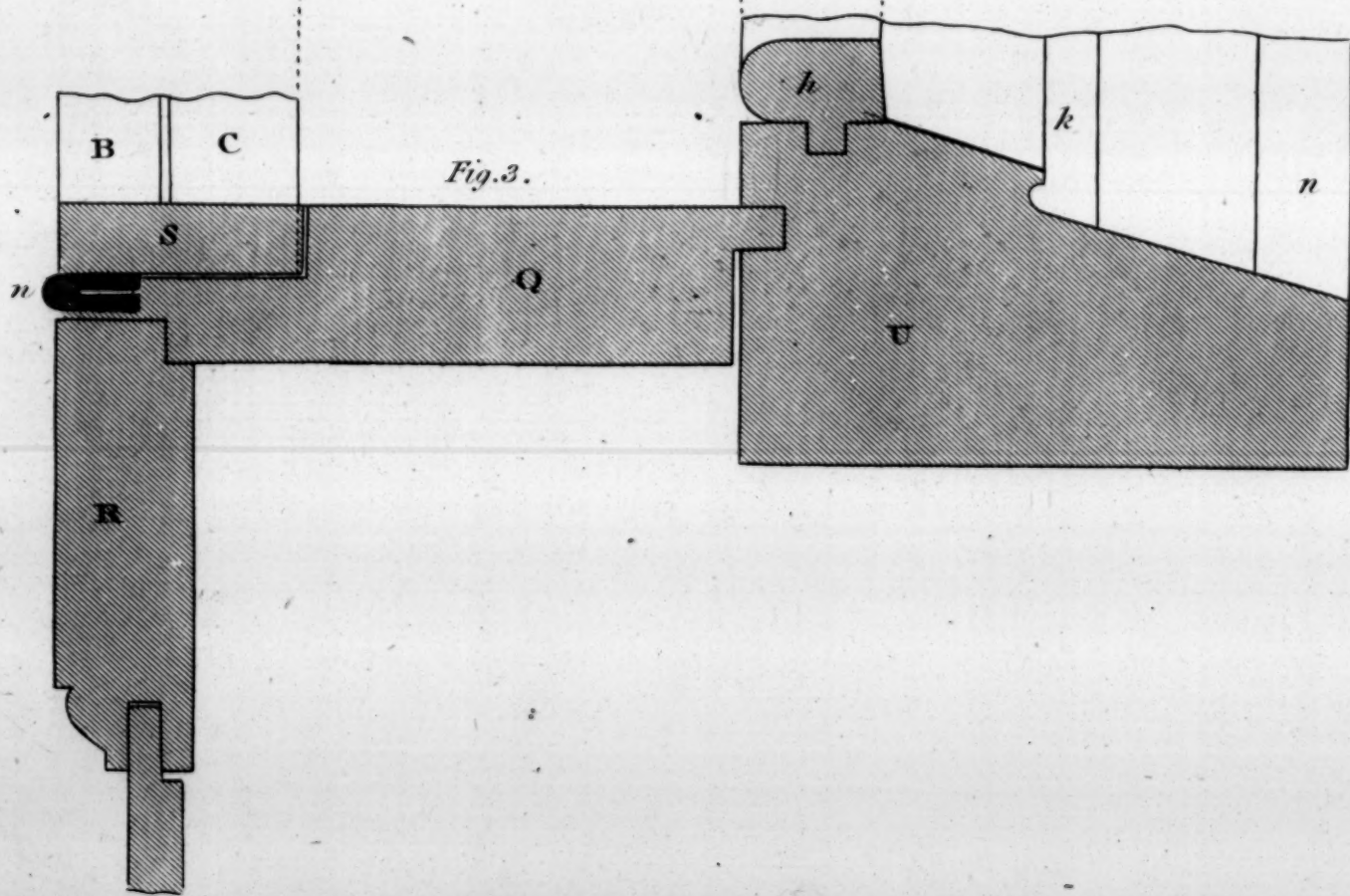
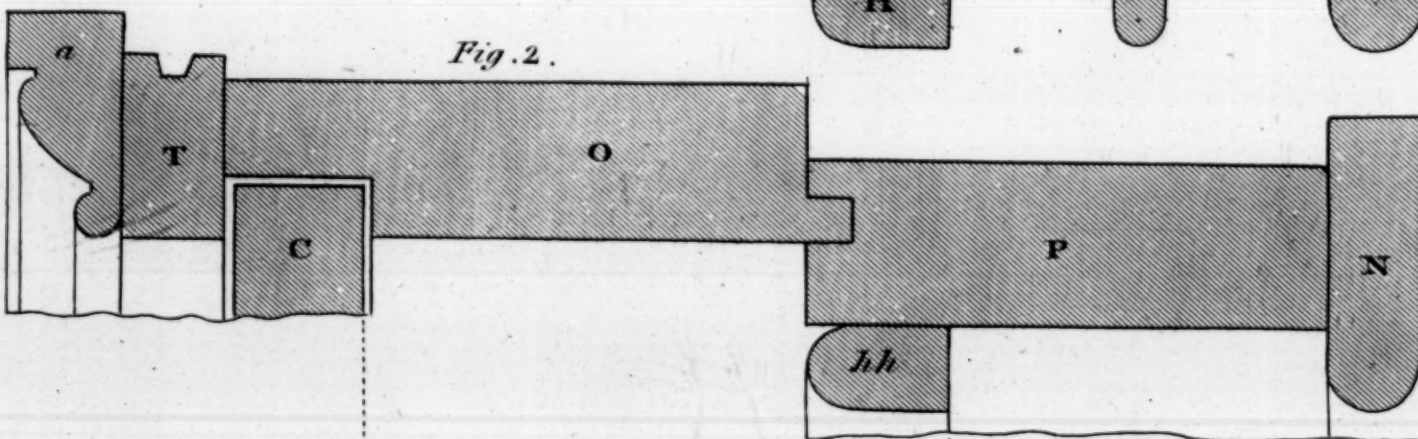
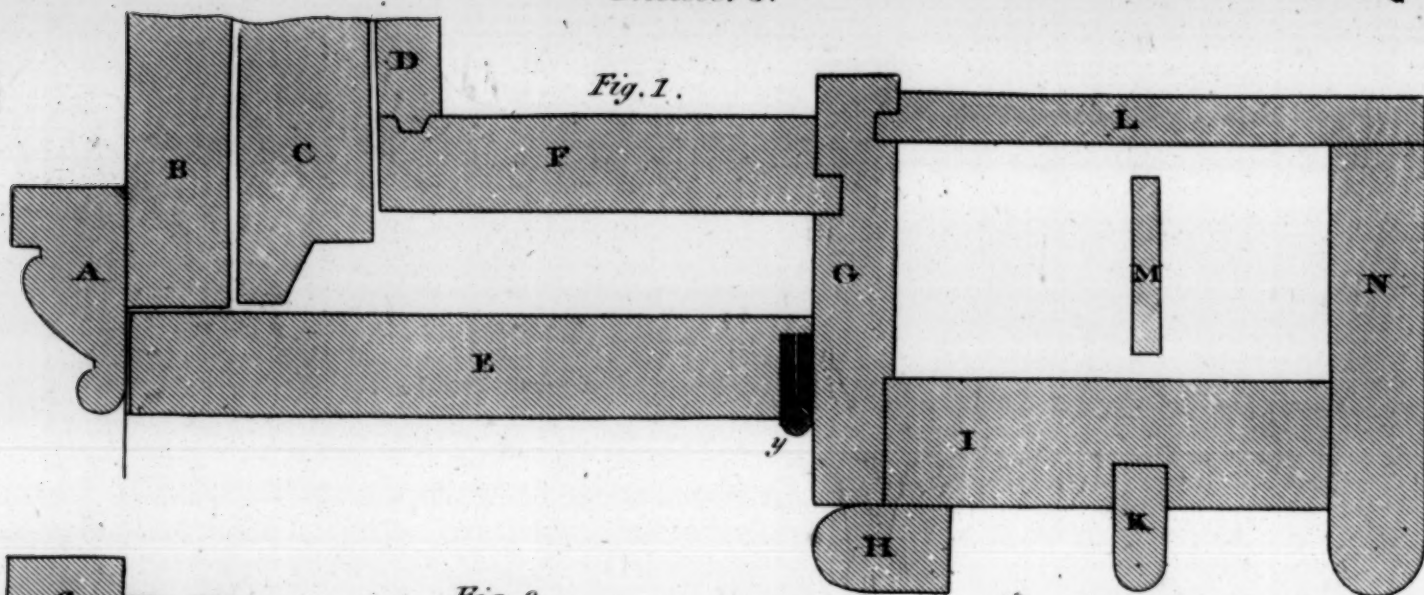


PLATE LI.

SHUTTERS.

Different sections of the foregoing plate.

FIG. 1, horizontal section through the side of the window.

- A*, architrave moulding.
- B*, part of a piece of framing.
- C*, part of the shutter.
- D*, plaister or rendering upon the wall.
- E*, the front shutter hung to the sash frame at *y*.
- F*, back lining.
- G*, inside lining of the sash frame.
- H*, inside bead of the sash frame.
- I*, pulley piece.
- K*, parting bead.
- L*, back lining of the sash frame.
- M*, parting stripe.
- N*, outside lining.

FIG. 2, vertical section through the top of the window.

- a*, architrave moulding.
- T*, ground over the window.
- C*, section of part of the shutter.
- O*, soffit.
- P*, top of the sash frame.
- N*, horizontal outside bead.
- bb*, inside horizontal bead.

FIG. 3, vertical section through the fill of the window.

- B*, edge of the framing.
- C*, edge of the shutter.
- Q*, fill rabbetted out at *S*, and tongued into the sash frame fill.
- S*, a flap hung to *Q*, by means of the hinge, at *n*; then by turning the front shutter upon the window, and by turning up the small flap *S*, there will be a clear passage for the shutter *C* to run in.

PLATE

PLATE LII.

SHUTTERS.

Plan, elevation and section, of a window with shutters, which will show uniform and complete whether the shutters are open or shut.

FIG. 1, plan or horizontal section at *A B*, fig. 2.

FIG. 2, elevation or front of the window.

FIG. 3, vertical section at *C, D*, fig. 2, and side of the window.

E, thickness of the pilaster or architrave.

F, a bead stuck on its edge parting the edge of the pilaster from the shutter.

G, the breadth of the shutter.

H and *I*, a bead and square to correspond to the thickness of the architrave and bead, so as to show the same finish on each edge of the shutter; one edge of this finishes against the sash-frame above, and the same edge below finishes against the back of the window down to the plinth.

K, another square equal to the projection of the capping.

L, bead of the sash-frame.

M, thickness for the under sash to run in.

N, parting bead.

O, the thickness for the upper sash to run in.

P, outside lining and bead.

Q, the thickness of the outer brick work.

This is further explained on the next plate.

The principal sections are shown to a larger scale in the next plate.

a a, lintles made of strong yellow deal or oak.

b, the top of the ground.

c, the architrave fixed upon the ground *b*.

d d, the soffit tongued into the top of the sash-frame *e*, and on the other edge into the head architrave *C*.

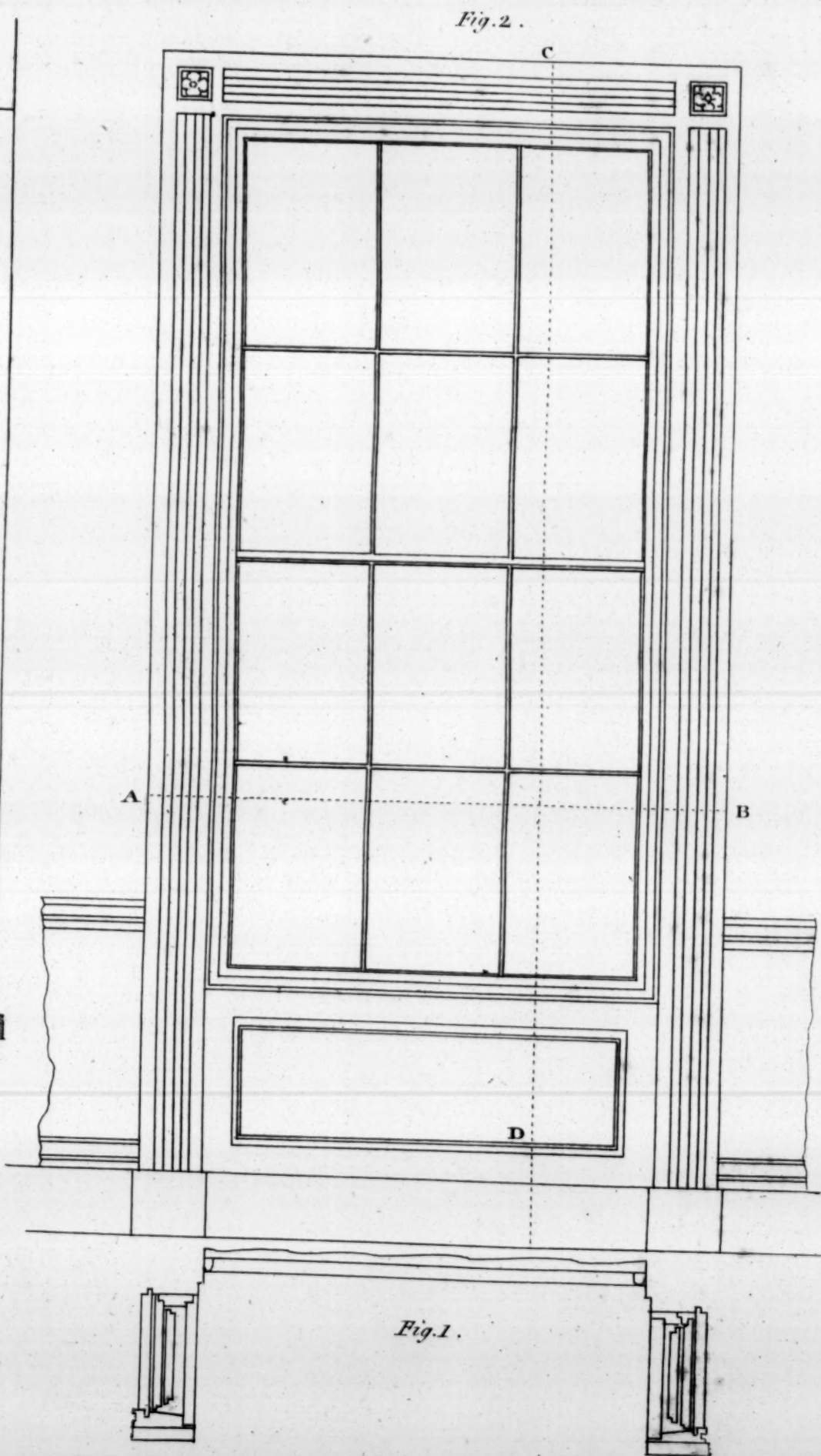
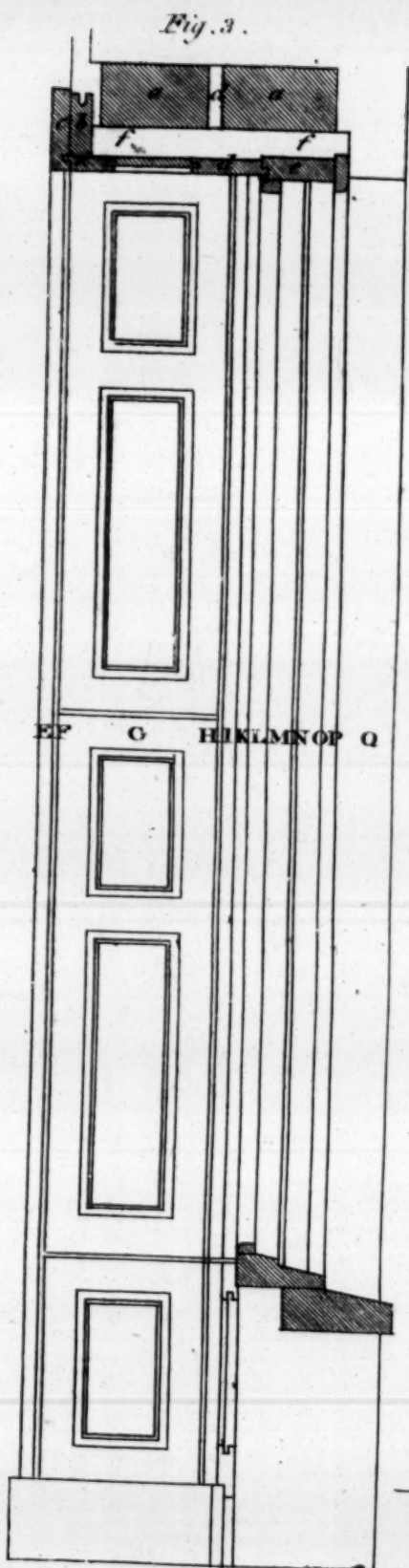
f f, a hollow space between the soffit *d d*, and the lintles *a a*; the under edges of the lintles *a a*, are generally about four inches and a half above the camber of the outside of the window; but it may be less when there is any necessity for it, as for example, when you have very narrow grounds it may come down within a quarter of an inch of the soffit.

The face of the pulley stile of every sash-frame ought to project beyond the edge of the brick-work about three-eighths of an inch; that is, the distance between the face of each pulley stile ought to be less by three-quarters of an inch than the width of the window on the outside, so that the face of the shutters ought to be in the same plane with the brick work on the outside.

PLATE

Shutters.

Pl. 52.







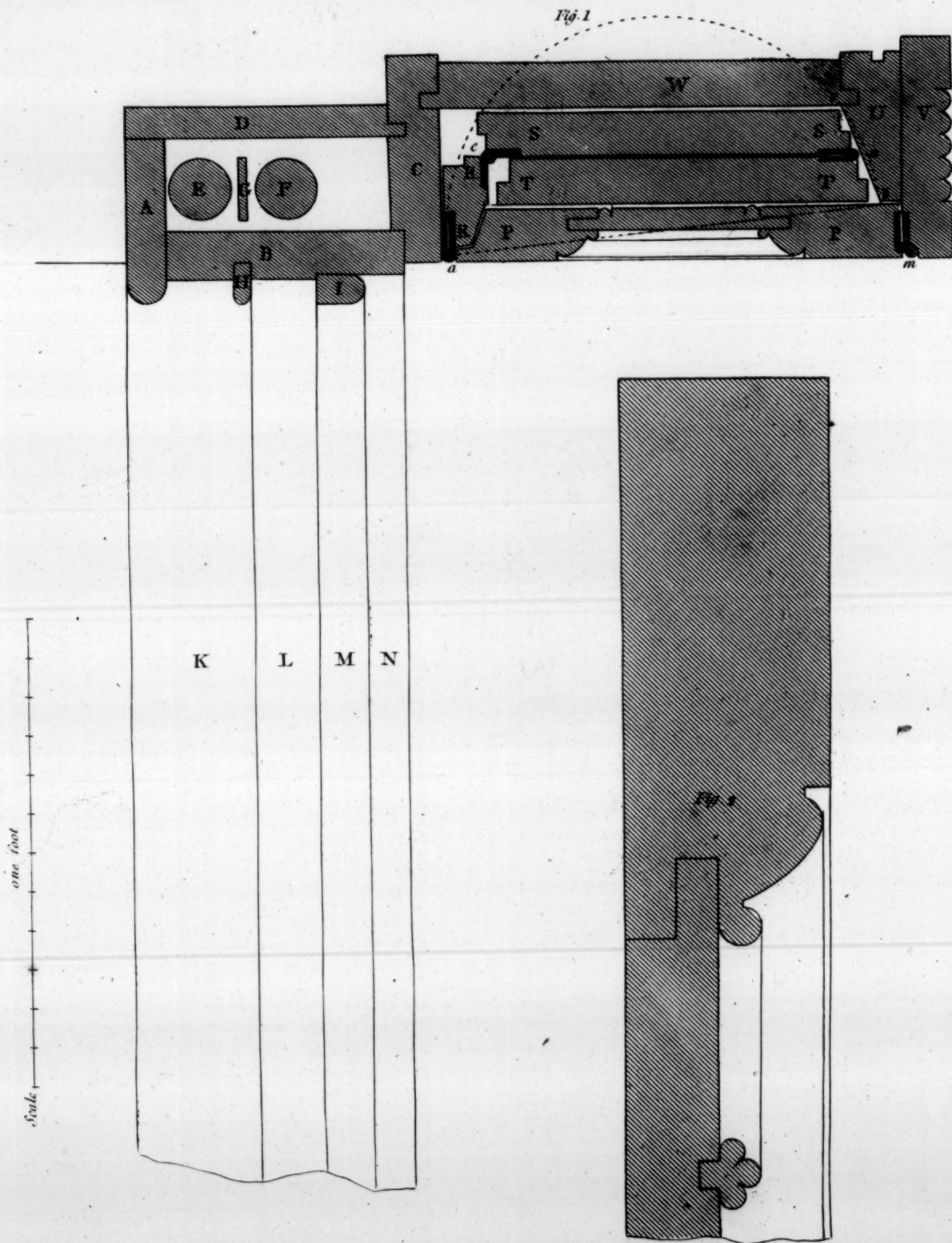


PLATE LIII.

SHUTTERS.

Parts of the foregoing at large.

FIG. 1, plan of the shutters.

A, the outside lining.*B*, the pulley piece.*C*, inside lining.*D*, back lining and outside bead.*E* and *F*, weights.*G*, parting strip.*H*, parting bead.*I*, inside bead.*K* and *L*, plan of the sash-frame.*M*, plan of the inside bead.*N*, plan of the capping.*R R*, a hanging stile hung to the sash frame at *a*.*S S*, a shutter hung to the hanging stile at *e*.*T T*, another shutter hung to *S S* at *n* if necessary.*P P*, a door hung to the architrave at *m*, falls upon the hanging stile *R R* by means of a rabbet.*Note*.—The door must fall in a rabbet at top and bottom.*U*, a ground to fix the architrave upon.*V*, the architrave fixed upon the ground.*W*, back lining.

When the window is to be shut in, the door *P P* is to be turned round the hinge *m*, parallel to the face of the sash-frame.

Then the shutters *R R*, *S S*, *T T*, being turned out on the hinge *a*, and on their several hinges, will cover that part of the window for which they were intended. The door *P* may then be closed, and the whole will have a uniform and neat appearance.

To find the splay of the ground b c.

Draw a line from the centre of the hinge at *a* to the edge of the ground at *b*; on *a b*, as a diameter, describe a circle cutting the back lining of the boxing at *c*; join *c b* and it will be the bevil required.

PLATE

PLATE LIV.

SHUTTERS.

Front and two side elevations of a window, the sash frame, being out of the square, or an oblique angled parallelogram; showing how to construct the sides of the window, so that the shutters shall make an equal margin round the edge of the sash frame when the window is shut; and also to fit their boxings.

FIG. 1, elevation of the window; $A B C D$ being the edge of the sash frame next to the bead, and $E F G H$ the margin for the window shutters.

The difficulty of fitting up a window of this kind may be surmounted if the following observations are attended to: the points K and I , fig. 3, being taken at the distance $E F$, fig. 1, and the point R , fig. 3, being made to correspond to K , fig. 1, the middle of the meeting rails, then

Make the angle $R H L$, fig. 3, equal to the angle $K E H$, fig. 1; through R and I draw $R S$ and $I M$ parallel to $K L$; then $K I M L$ will be the front shutter, and $R S$ the parting bead, in case the shutters are to be cut.

FIG. 2 is constructed in the same manner as fig. 3; that is, by making the angle $T O P$ equal to the angle $E H L$, fig. 1; the points $O T N$ being previously made to correspond to $H L$ and G , as on the other side.

FIG. 3, A and B , lintles.

C , the top of the sash frame.

D , the soffit.

e , ground.

G , sash frame fill.

F , stone fill.

PLATE LV.

SHUTTERS.

Plan and elevation of the shutters to the foregoing example; showing the manner of hanging and cutting the shutters when the sash frame is an oblique angled parallelogram, or out of the square, as workmen call it.

Let $D C$ and $A B$, fig. 2, be the top and bottom ends of the shutters parallel to each other; now, in order that the shutters may fit close into their boxing, and also close into the window-frame, the centres of the hinges to each flap must act in lines perpendicular to $D C$ or $A B$.

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Shutters.

Fig. 1.

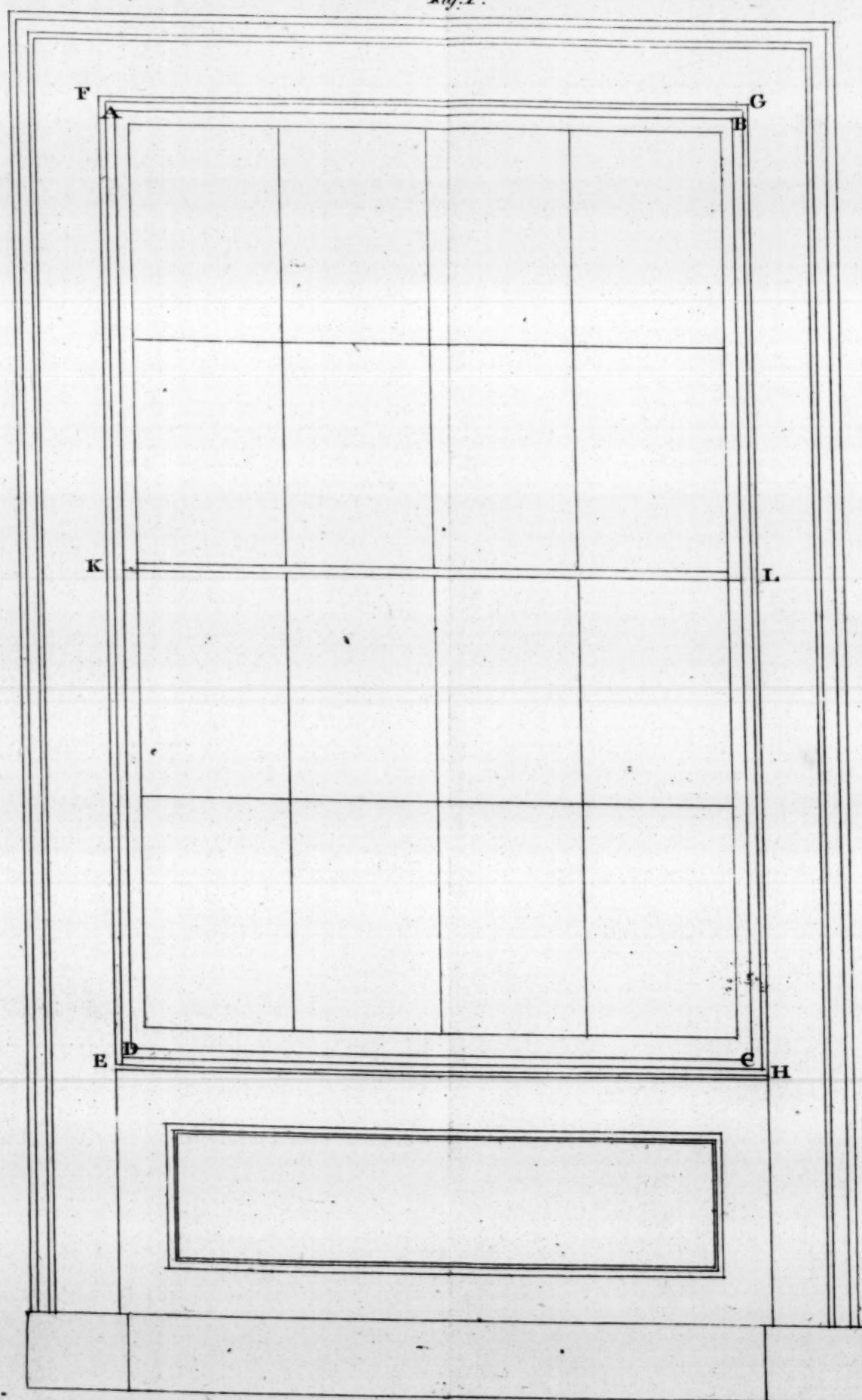


Fig. 2.

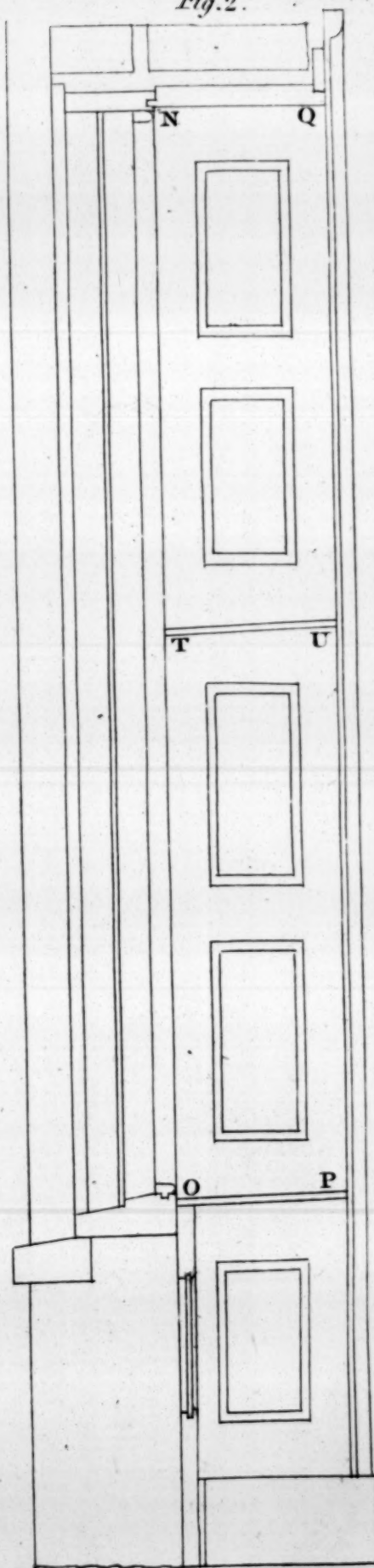
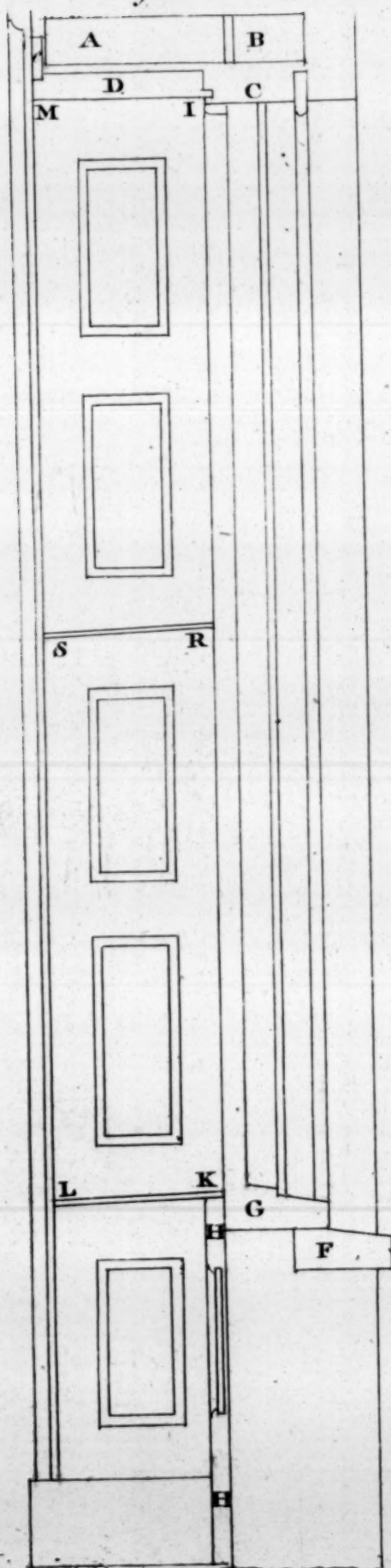


Fig. 3.





Shutters.
Fig. 2.

Pl. 55.

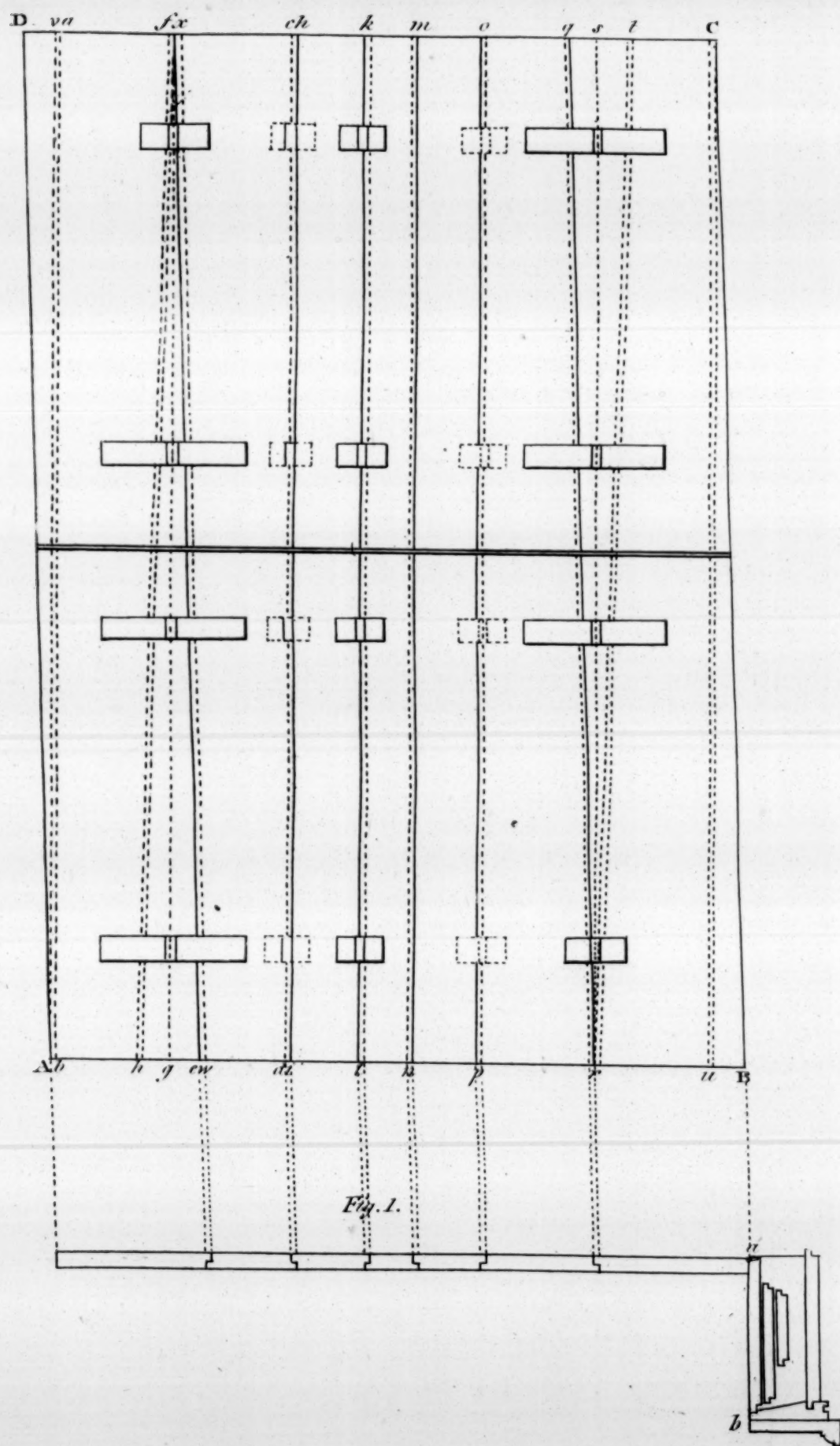


Fig. 1.



How to set out the shutters.

Make Ae and Df , fig. 2, equal to the breadth of the front shutter ab , fig. 1, and draw the line fe ; then will $ADfe$ represent the front shutter, and fe the edge on which the next flap will join to it; then if the angle Dfe be not a right angle but obtuse, from f draw fg perpendicular to DC ; then will fg be the line on which the centres of the hinges must be placed. In the same manner $BCqr$ will represent the shutter on the other side; Brq being the obtuse angle, and rf a perpendicular to AB for the centres of the hinges for the joint qr : these two extreme joints being done, all the other joints bi , kl , mn , and op , ought to be all perpendicular to the ends DC and AB of the shutters: then will the centres of the hinges be parallel to, or in the same line with, the joint.

How to find the breadth of the flaps which hang to the front shutters, so that they may be as wide as possible.

From the points A and C , the obtuse angles, draw Av and Cu perpendicular to the lines, or ends of the shutters, AB and DC ; make va and Ab equal to the breadth of the rabbet; and from the point f , and in the line of the centres of the hinges, make fa , fb , and gd , gi , respectively, equal to fa , fv , and gb , gA ; then will $efbi$ be the flap required; and it is plain from the nature of this window, that the other flap $oqrp$ must be the same figure as the flap $efbi$, but inverted.

The other flaps may be filled in as the width of the window will admit.

Note.—I have given this example, not that I would in so distorted a case consider it as worth the trouble it must necessarily cost (it would be better certainly to rebuild it), but because the method is a general one and will apply to all cases, and because I would advise the accurate workman never to trust to the sash-frame being absolutely square, for they seldom are; and if the variation be ever so small, there will be a very considerable error in the ends of the shutters when inclosed in the boxings, if the rule contained in this example be not attended to.

PLATE LVI.

OF DIMINISHING AND ENLARGING MOULDINGS, &c.

From a given Entablature or Cornice, to draw another similar to it, of any given height.

Let $A b$ be the height of the given entablature; from b , in $A b$, draw $b a$, making any angle with $A b$ from b ; make $b a$ equal to the height of the intended cornice; join $A a$, then from all the heights on $A b$ draw lines parallel to $A a$, cutting $b a$, and from these points in $a b$ draw perpendiculars; then, in order to find the projections, bring all the projections of the given cornice to the line $D E$, and from the projections in the line $D E$ draw lines to B ; make $B K$ equal to $b k$, and draw $K L$ perpendicular to $B K$, cutting all the projections drawn from $D E$ to the point B ; from k draw $k f$ perpendicular to $b k$; from k make all the distances from k to f equal to the corresponding distances from K to L , which will give the projections of the cornice. In the same manner may the projections of the architrave be found, as is plainly shown by the corresponding letters $G H$ and $g h$.

PLATE LVII.

RAKING MOULDINGS.

How to describe all kinds of raking mouldings for pediments, whether straight or circular.

FIG. 1. Elevation of a circular pediment.

FIG. 2. Elevation of a triangular or straight pediment.

How to describe the raking mouldings of pediments, such as fig. 1 and 2, for working the face or front moulding.

FIG. 3 and 6. Let $B c b a A$, at No. 1, be the given moulding; in it take any points $a b c$ at pleasure; from these points draw lines $c c c$, $b b b$, and $a a a$, parallel to the fillets $B B B$ or $A A A$ of the pediment; from the points $A a b c B$ draw the perpendiculars $A D$, $a d$, $b e$, and $c f$; draw any line $D E$ at right angles, to $A D$, $a d$, $b e$, $c f$ and $B E$, cutting them in the points D , d , e , f , E .

In fig. 3, draw any line $A D$ at right angles to the rake, cutting one edge of the upper fillet at D , No. 2; from D , No. 2, make the several projections $d e f E$ equal to $d e f E$



Raking Mouldings.

P157.

Fig.1.

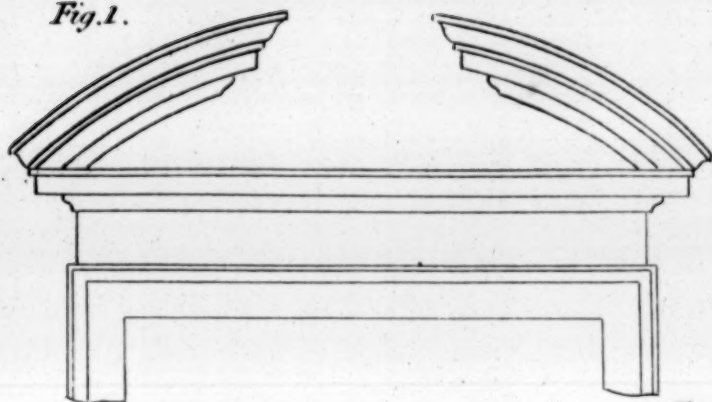


Fig.2.

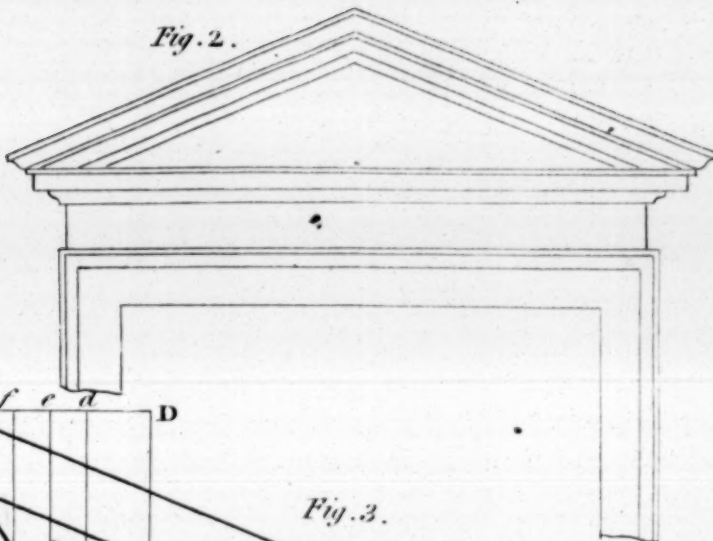


Fig.4.

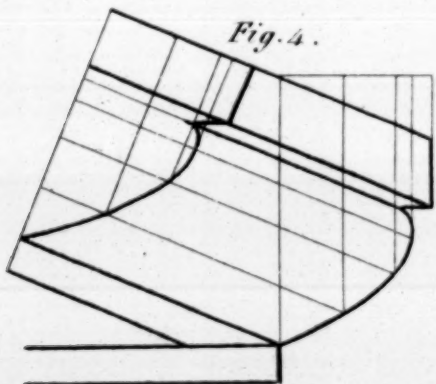


Fig.3.

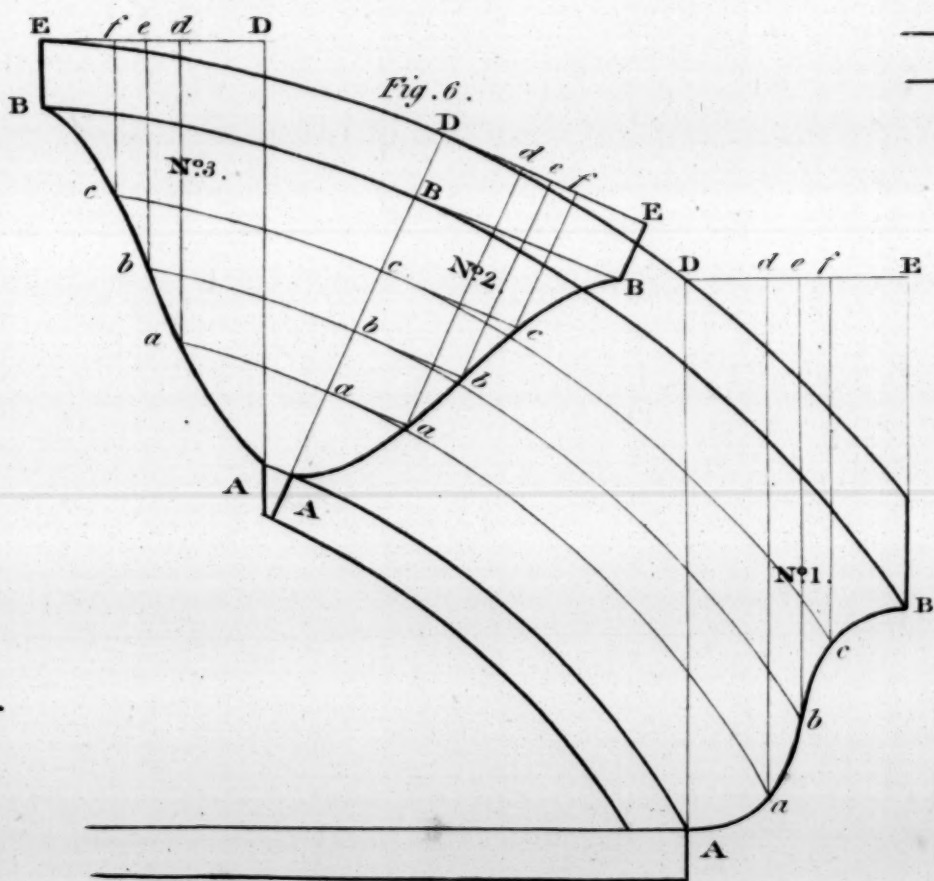
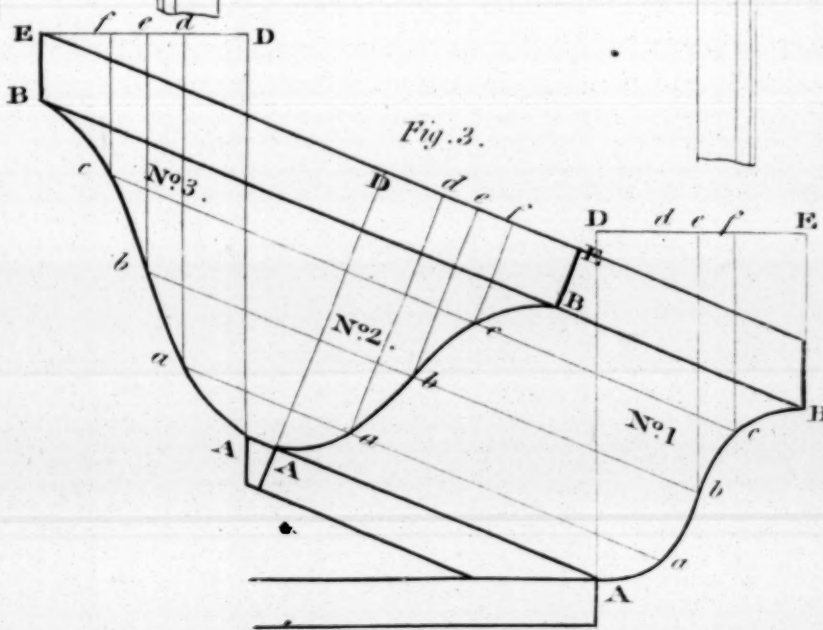
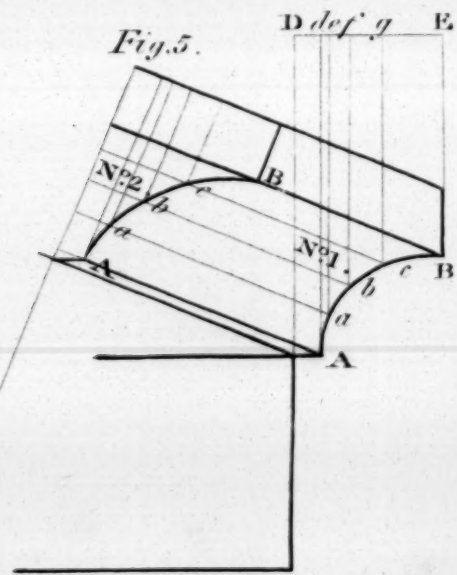


Fig.5.

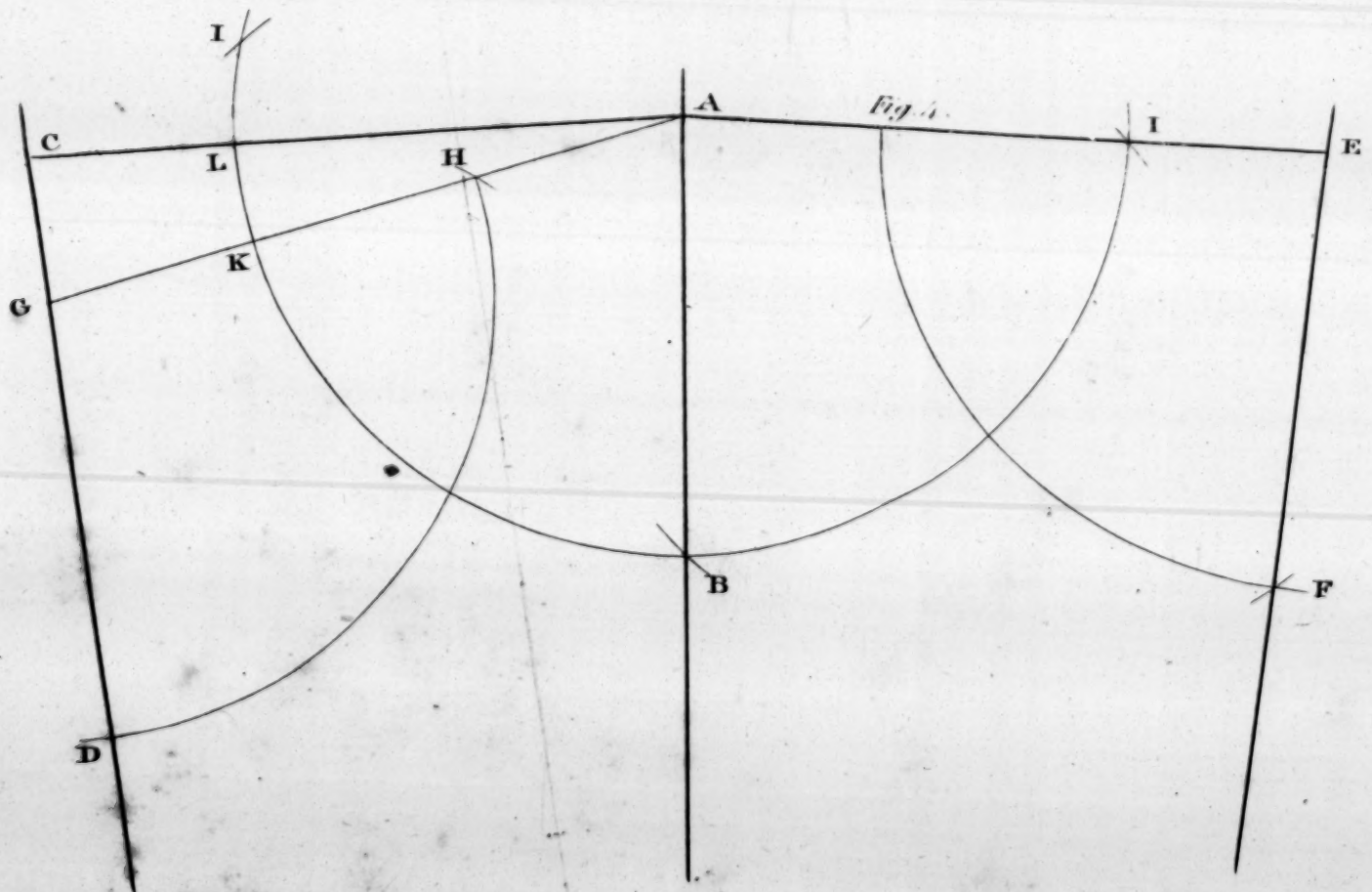
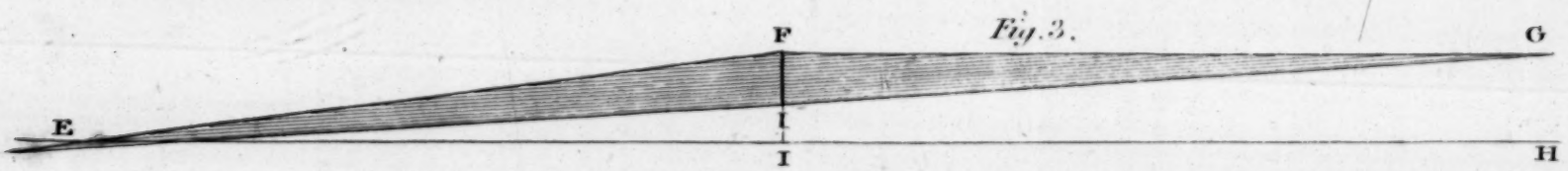
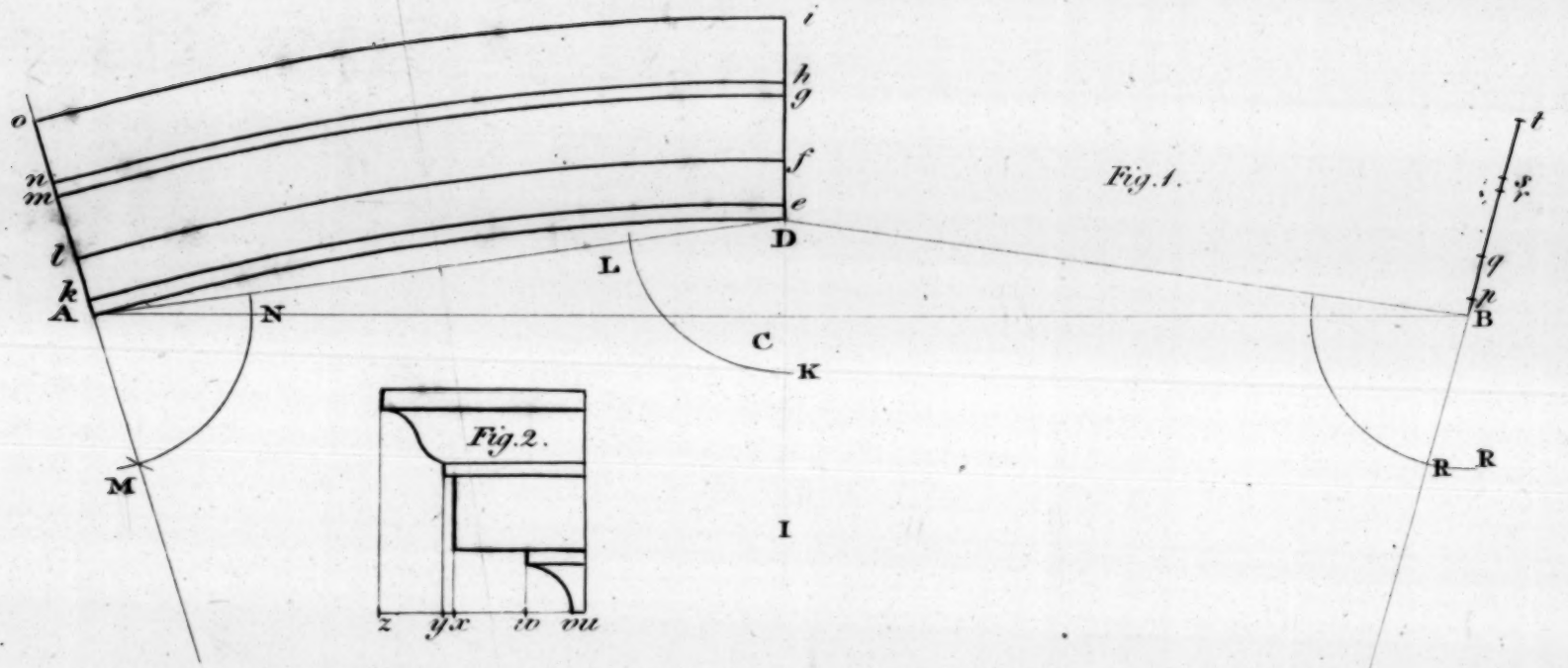






Setting out Shop Fronts

Pl. 58.



at No. 1; in No. 2 draw the perpendiculars AD , ad , be , cf , and BE , cutting BBB , ccc , bbb , aaa , at the points a , b , c , and it will give points in the curve through which it may be traced.

In *fig. 6* draw any line AD to the centre of the pediment, cutting the lines AAA , aaa , bbb , ccc , BBB , and DE at A , a , b , c , B , D ; from these points draw lines DE , BB , cc , bb , and aa tangents to their respective curves; then make all the projections $DdefE$ in No. 2, equal to those at No. 1, and from the points $DdefE$ at No. 2, draw lines parallel to AD , cutting the tangents in the points $abcB$, through which points the curve may be traced.

How to find the return moulding at the top in fig. 3 and 6.

Draw any line DE at No. 3, parallel to DE , No. 1, making all the projections from D to $defE$, at No. 3, equal to their corresponding distances $DdefE$ at No. 3; from the points $defE$, in No. 3, draw the perpendiculars DA , da , eb , fc and EB , cutting BBB , ccc , bbb , aaa , and AAA , at the points $AbcB$, will give points in the curve through which it may be traced.

FIG. 4 and 5, want no other explanation than what has already been described to *fig. 3* and 6, as they differ only in form, and not in method.

PLATE LVIII.

OF SETTING OUT SHOP FRONTS ON A CIRCULAR PLAN.

How to draw a cornice or moulding of any kind, which is a very flat segment of a circle on the plan.

Let AB , *fig. 1*, be the length of the segment, and CD the projection; join DA and DB ; make the angles DAM and DBR equal to the angle ADC ; continue MA at pleasure to O ; also produce CD to i and RB to t , make the distances Ak , Al , Am , An , AO , and De , Df , Dg , Dh , Di , likewise Bp , Bq , Br , Bs , Bt , equal to the projections of the cornice, *fig. 2*, at u , v , w , x , y , z ; then make a triangular piece of thin board, *fig. 3*, EFG , in the following manner: that is, make EI equal to AC , and IF perpendicular to it equal to CD ; join EF , and draw FG parallel to EI ; make FG equal to FE , or more if you please; join GE ; then will EFG be the form of a piece which will describe all the arcs AD , ke , lf , mg , nh , and oi , which will give one half of the cornice; the other half will be described in the same manner.

G 2

Given

Given two straight lines inclining to each other, and a point in one of them, to find a point in the other, so that if both lines were produced till they meet each other, the point of intersection of the two lines may be the same distance from each point; also to find a third point, which shall be equally distant from the intersection, and also from the other points.

FIG. 4. Let AB and CD be the two lines given, and A the given point; through A draw any line AG , cutting CD in G ; on G , as a centre, with any radius, describe the arc HD , cutting GA and GD in H and D ; on A , with the same radius, describe the arc BKL , cutting AG at K ; make BI equal to DH ; bisect KI at L , and draw ALC , cutting DC , produced at C , another point in the circumference; make the angles EAB equal to the angle LAB ; make AE equal to AC , and the point E will be the third point required.

PLATE LIX.

STAIR-CASES.

How to draw a scroll of a hand-rail to any number of revolutions that the width of the rail will admit.

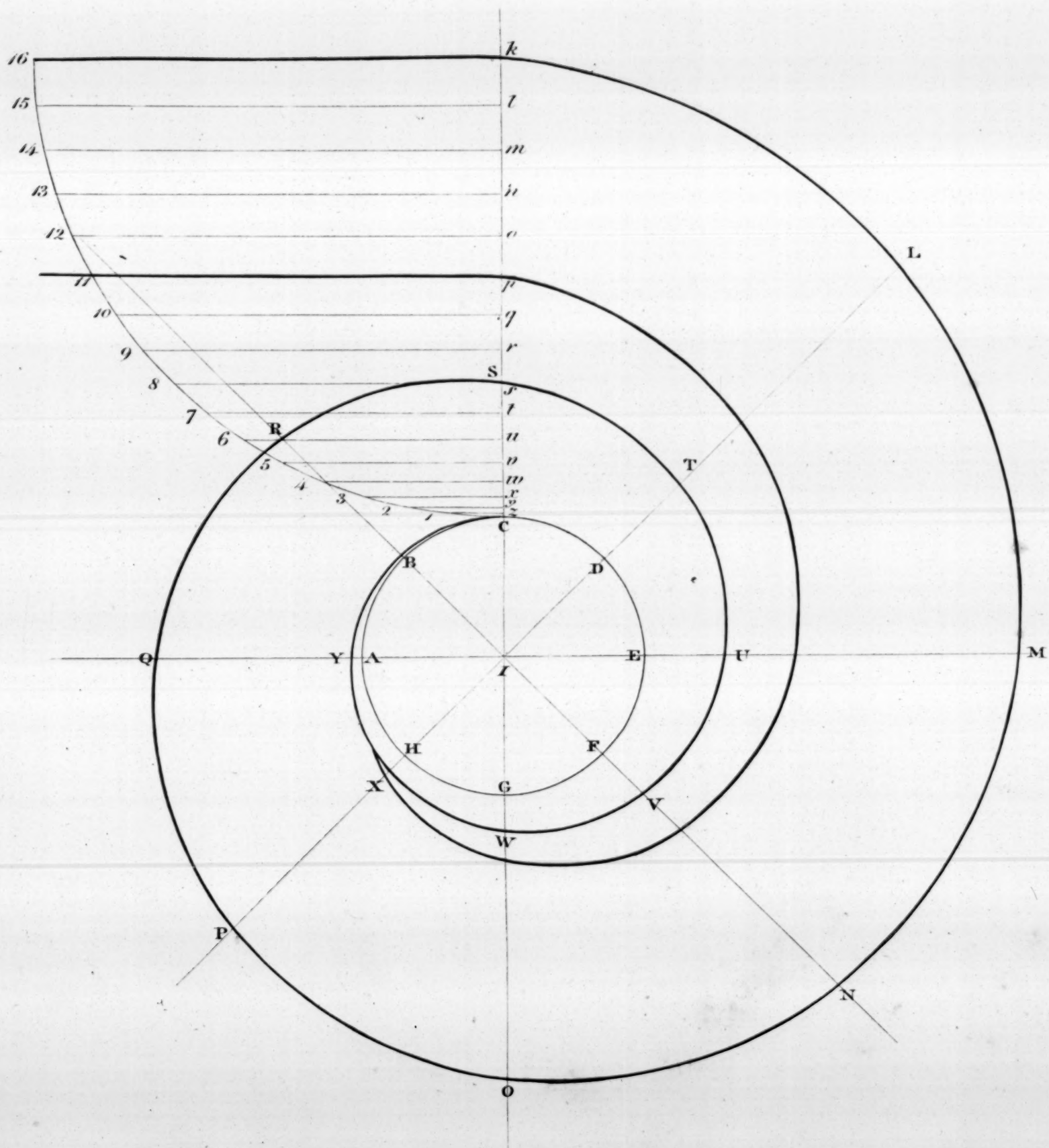
Draw a circle $ABCDEFGH$, about three inches diameter, and divide the circumference into as many equal parts as you may think necessary; in this example it is in eight parts, at the points A, B, C, D, E, F, G , and H ; through all these points, and from the centre I , draw lines QM, PL, OS, NR : now suppose that Ik is the distance you intend the centre of the scroll to be from the beginning of the twist; from k draw $k16$ perpendicular to Ck ; on k , with the radius kC , describe the quadrant $C12345$, &c. cutting kC at C , and $k16$ at 16 : now suppose it were required to make two revolutions in this scroll, and since every revolution contains eight parts, there must be 16 in two revolutions; therefore divide the quadrant into 16 equal parts, and draw lines $15l, 14m, 13n, 12o, 11p$, &c. perpendicular to kC , cutting it at l, m, n, o , &c; from I make IL, IM, IN , &c. equal to their corresponding distances Il, Im, In, Io , &c. and trace a curve round these points to the eye.

The outside curve being now formed, the inside one will be easily obtained by setting the thickness of the rail from the point K, L, M, N , &c. towards the centre I , and a curve being traced round these points will give the inside of the rail.

PLATE

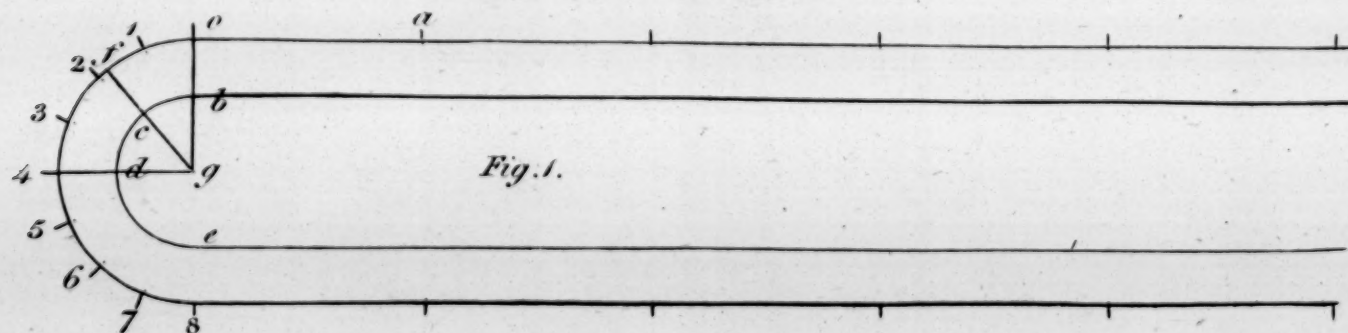
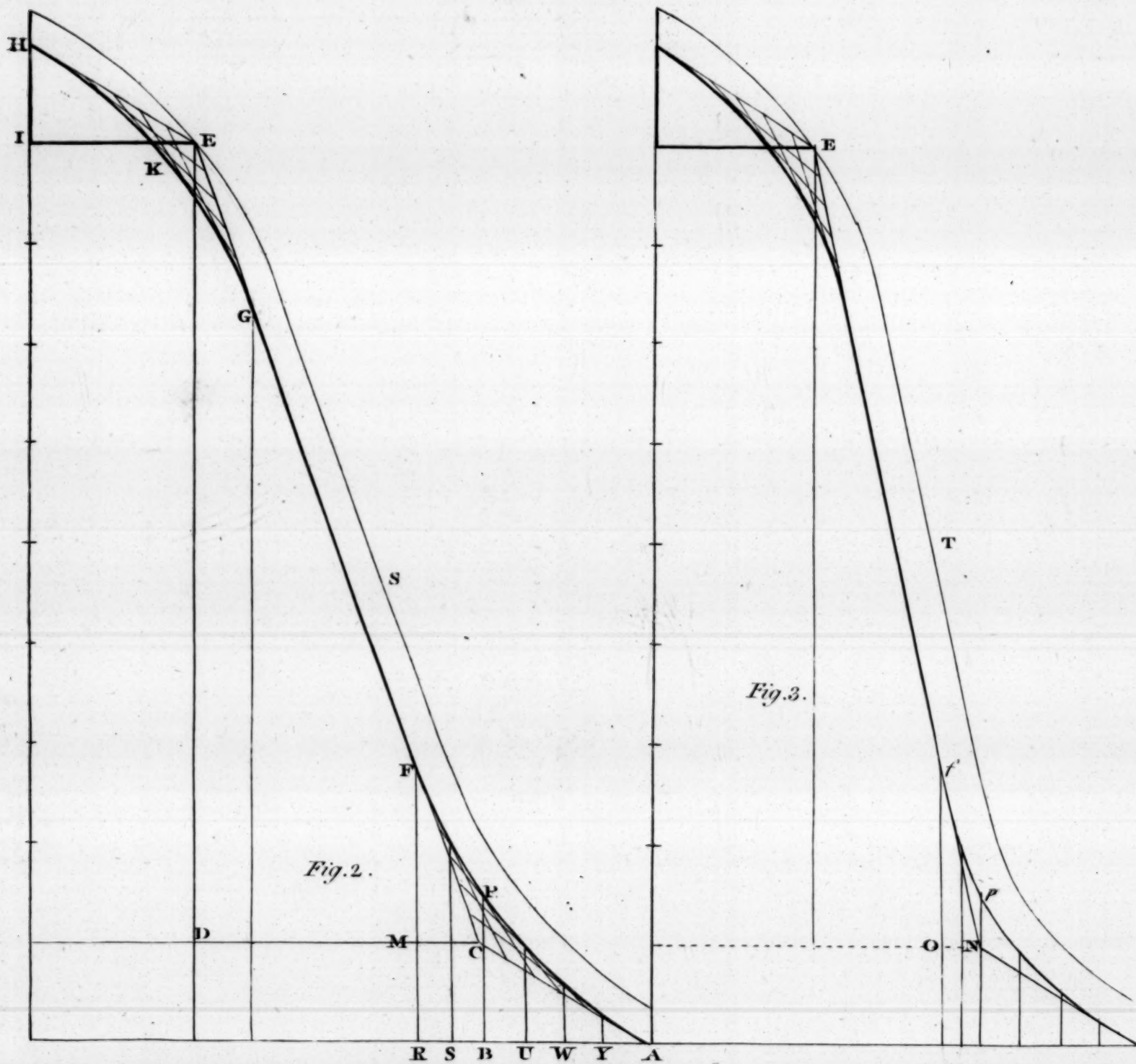
Stair-Cases.

Plan











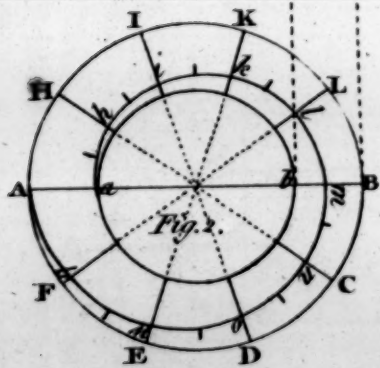
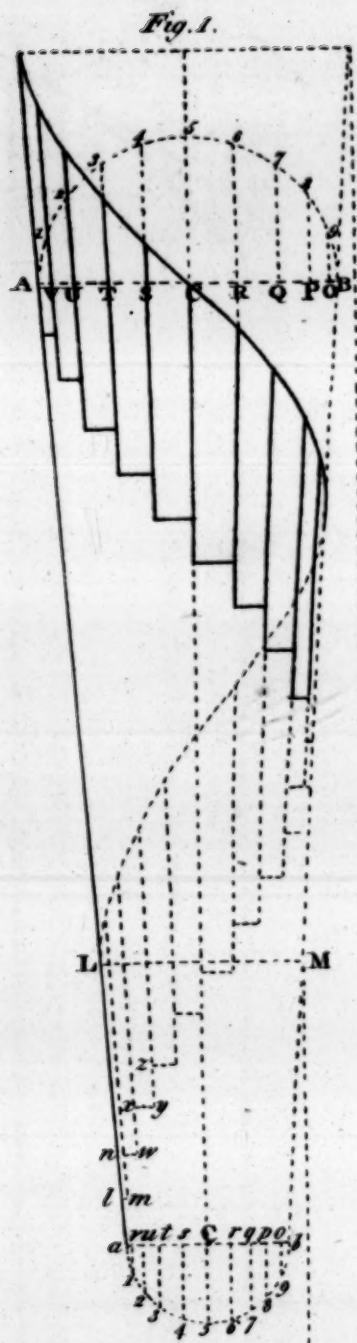


Fig. 5.

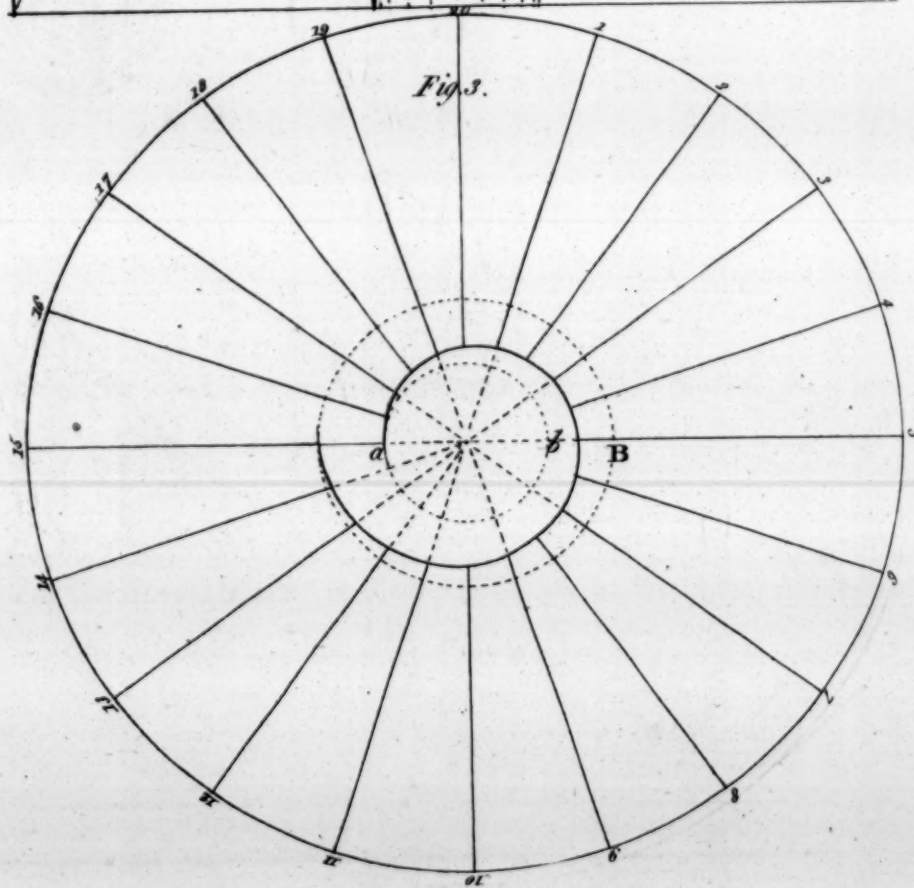
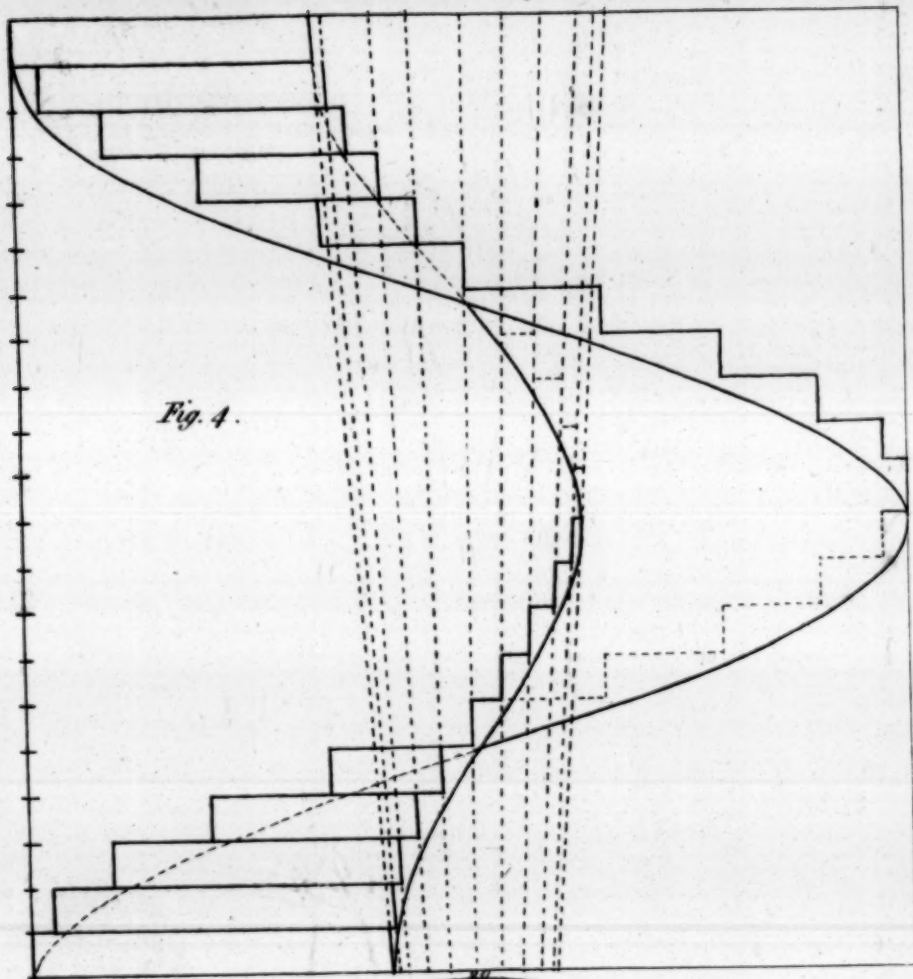


PLATE LX.

STAIR-CASES.

How to find the form of the veneers for gluing a rail in thicknesses.

Let *fig. 1*, be the plan of the rail, and the points 0, 1, 2, 3, 4, 5, 6, 7, 8, be the ends of the steps on the winders. Let *a o* be one of the slips on the flyers. Let *ABC* be the pitch-board, *fig. 2*, of the flyers; from *C* draw *CD* perpendicular to *CB*, and make *CD* equal to the circumference of the circular part round 0, 1, 2, 3, 4, 5, 6, 7, and 8; through *D* draw *DE* perpendicular to *DC*; then with your height-rod set up the heights of as many steps as you have winders, which in this example is eight; join *EC*; from *E* apply the pitch-board *EIH*, whose base *EI* is perpendicular to *ED*; from the points *E* and *C*, in the line *EC*, make *EG* and *CF* each equal to the hypotenuse of the pitch-board, that is, *AC* or *EH*; then describe the parabolas *HKG* and *FRA*, which will complete one edge of the falling mould; the other edge will be completed by drawing the line parallel to it; the other falling mould, *fig. 2*, will be completed in the same manner, only with this difference, by taking the circumference round the inside at *b c d e*, instead of 0, 1, 2, 3, 4, 5, 6, 7, 8; take *MC*, *fig. 2*, and apply it from 0 to *f* in *fig. 1*; then draw *fg*, cutting the inside of the rail at *c*; then take *bc* and apply it from *N* to *O*, by which means the curve from *P* to *Q* may be traced from *R* to *F*, and the whole curve *azxvPtQ* may be traced from *AZ XVRTF*, as follows; divide the bases *AB* and *ab* of the pitch boards, *fig. 2* and 3, into the same number of equal parts; draw ordinates *YZ, WX, UV, BR*, in *fig. 2*, and *yz, wx, uv, bp*, in *fig. 3*; draw *FR*, parallel to *BP*, in *fig. 1*, and *rf*, parallel to *bp* in *fig. 2*; divide *RB* *fig. 2*, and *rb*, *fig. 1*, each into two equal parts, or any other number of like parts at *S* and *s*, draw *ST* and *st* parallel to *BP*, and *bp*; then make all the ordinates *rf, st, bp, uv, wx*, and *yz*, equal to the corresponding ordinates *RF, ST, BP, UV, WX*, and *YZ*; then a curve being traced through the points *a, z, x, v, p, t, f*, will give the true curve of the under side of the falling mould in *fig. 3*, to correspond exactly to the under edge *AZ XVPTF*, of *fig. 2*.

PLATE LXI.

To draw the elevation of a hand-rail and the ends of the steps for stairs, the well-hole being the frustum of a cone.

On each end of the frustum, at *AB* and *ab* as diameters, describe a semicircle and divide the circumference of each into half the number of equal parts as there are intended to

to be steps; from the points 1, 2, 3, 4, 5, &c. draw lines perpendicular to AB and ab , cutting them at O, P, Q, R, S, T, U, V , and o, p, q, r, s, t, u, v ; divide the perpendicular height Cc into one part more than the number of steps on the plan; that is, divide Cc into 21 equal parts, which will give the height of as many steps; $a l$ will be the first step on the side Aa of the cylinder; $m n$ will be the end for the second step, by drawing a line from $V v$; $w x$ will be the end for the third step, by drawing a line from $u U$; and $y z$ for the fourth, until you get to the other edge of the frustum $b B$, which will complete one half of the flight; from thence you must draw the steps in the same order towards the side Aa for the other half.

To find the line of the hand-rail on the frustum.

From the top of each step draw lines in the direction $v V, u U, t T$, &c.; on each of these lines set up the height of the balusters from the top of each step upwards; and through these points trace a curve and it will give the line of the rail.

To draw the plan of the rail.

Draw a line AB , at *fig. 2*, equal to XY , the diameter of the frustum, *fig. 1*, at the top of the rail; divide it into two equal parts at c ; on c as a centre describe a circle $A H I K L B C D E F$, which will represent a section of the conical frustum through XY . Also take half LM , *fig. 1*; on c , *fig. 2*, as a centre, describe a circle cutting AB at a and b ; divide Aa into any number of equal parts, as 10; also divide the circumference of the outward circle, beginning at A , into as many equal parts at $A, H, I, K, L, B, C, D, E, F, A$, as the line or distance between the same diameters Aa is divided into; then draw the radii $c H, c I, c K, c L$, &c.; make cb equal to the radius ca of the lesser circle, and one of the parts of Aa ; ci equal to ca and two parts; ck equal to ca and three parts; proceed in this manner, augmenting each succeeding radius one part more than the preceding one; then a curve being traced through all the points, will give the plan of the rail.

To draw the plan and elevation of the stair-case.

This elevation of the well-hole, *fig. 4*, is found in the same manner as in *fig. 1*. The plan at the steps, *fig. 3*, is found in the same manner as *fig. 2*, by taking AB , *fig. 1*, for the diameter $v B$ of the outward circle at *fig. 3*, and ab the diameter of the lower end of the frustum, *fig. 1*, instead of XY and LM ; then the spiral line $abcdefghi klmnopqrstuv$ will be the plan of a line touching the under angles of the steps.

This stair-case is a complete circle, as in *fig. 3*, and the steps are equally divided round the circumference at 1, 2, 3, 4, &c. to 20; from these points draw lines tending to the centre, ending at the spiral line or plan of the rail; the elevation and ends of the steps in *fig. 4*, are found from the height-rod, and from its plan *fig. 3*.

FIG. 5, the stretch-out of the plan of the rail in *fig. 2*, which is explained on the next plate.



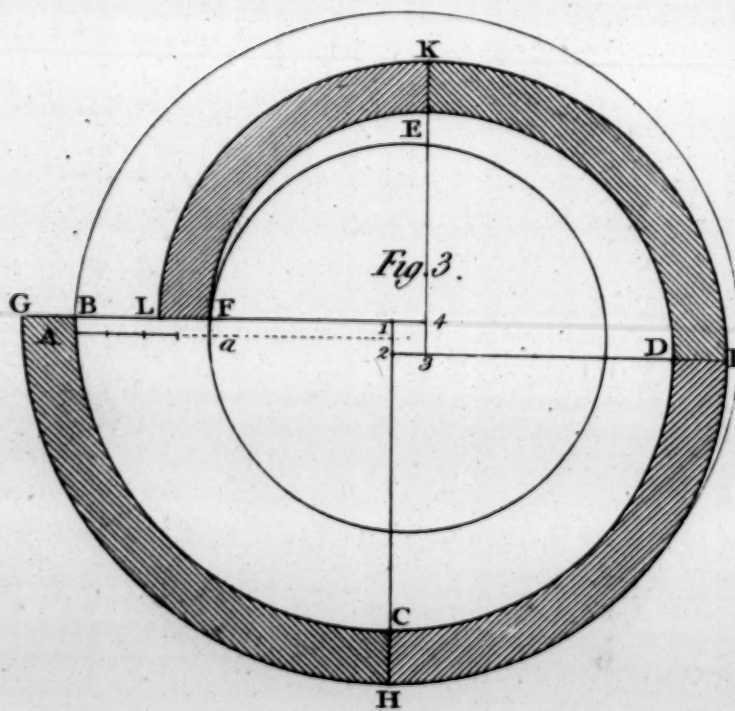
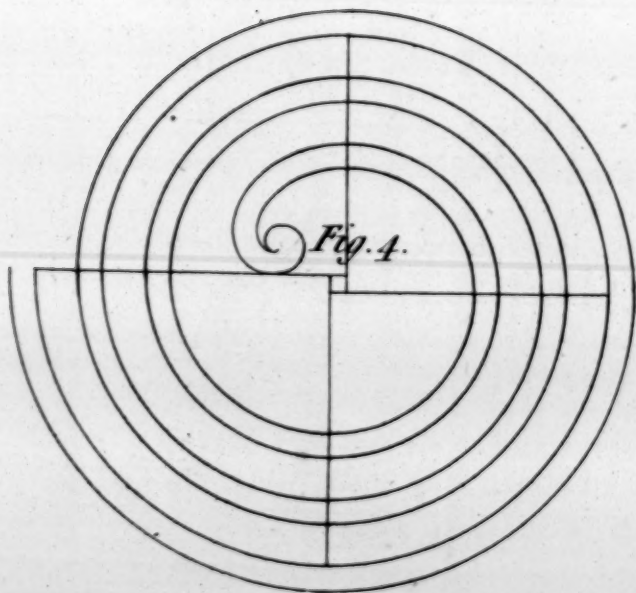
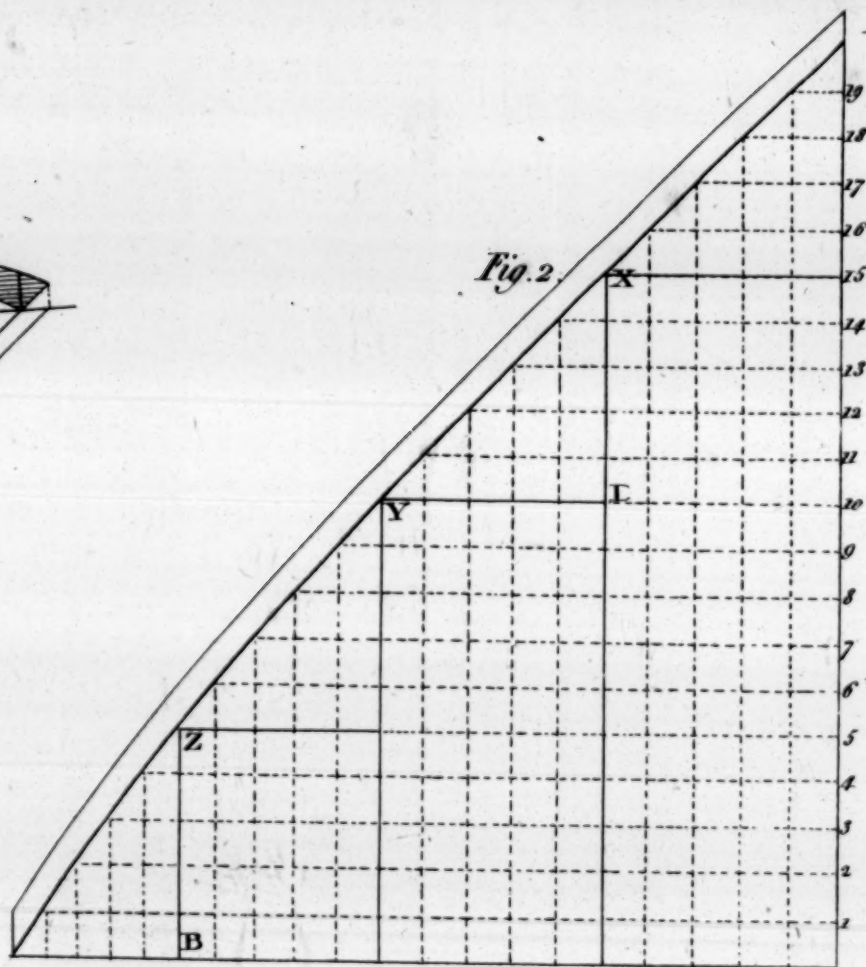
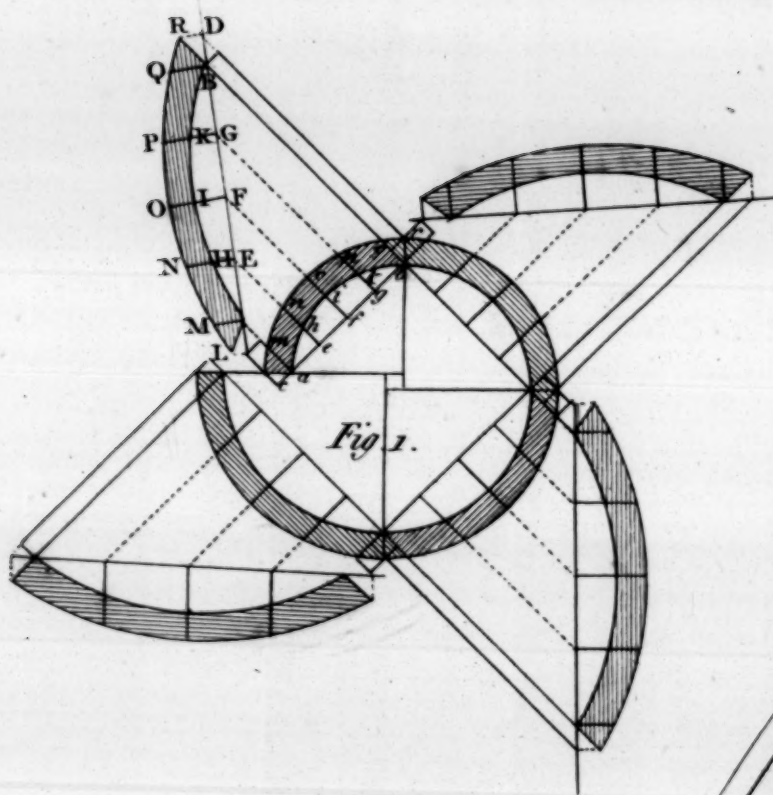


PLATE LXII.

To find the falling mould for the preceding stair-case.

Take the stretch-out of *fig. 5*, in the last plate, and apply it to *AV*, *fig. 2*, and mark all the steps upon that line, which are twenty in number; make *VW* perpendicular to *AV*, on *VW* set up the height of twenty steps; the dotted lines being drawn from the treads and heights of the steps, and a curve being drawn, will give the under edge of the falling mould.

To find the face moulds for each quarter of the rail.

Lay down the plan and thickness of the rail as *fig. 1*, the manner of finding the curve line of it for the inside of the rail has been shown in the last plate; then a line drawn equidistant round it, whose breadth is equal the thickness of the rail, will complete the plan, as is shown by the shaded part; divide the circumference round the inside of the rail into parts respectively equal, *AB*, *ZC*, *YD*, and *X* 15 in *fig. 2*; then to find a face mould for any of the parts, suppose *AB* on the falling mould, *fig. 2*, which corresponds to *ab*, on the plan *fig. 1*;

Draw the chord *ab*, and the joints *al* and *br*, cutting the outside of the rail at *l* and *r*; through the points *l*, *a*, *b*, *r*, draw perpendiculars *lc*, *aA*, *bB*, and *rd*, cutting *ab* at *c*, *a*, *b*, *d*; from the points *a* and *b* make *aT* and *bB* respectively equal to *Aa*, and *BZ*, *fig. 2*; through the points *T* and *B*, parallel to *ab*, draw *tC*, cutting *cLC* at *C*, and *drD* at *v*; through the points *C* and *B* draw *CB D*; take any number of intermediate points *e*, *f*, *g*, at pleasure, in the chord *ab*, and from these points draw lines *eE*, *fF*, *gG*, cutting *CB* at *E*, *F*, *G*; then from all the points *C*, *A*, *E*, *F*, *G*, *B*, *D*, draw lines perpendicular to *CD*; then make all the distances *EH*, *FI*, and *GK*, equal to their corresponding distances *eb*, *fi*, *gk*; and the distances *CL*, *AM*, *EN*, *FO*, *GP*, *BQ*, *DR*; then a curve being drawn through the points *A*, *H*, *I*, *K*, *B*, will form the inside of the mould, and another curve being drawn through *L*, *M*, *N*, *O*, *P*, *Q*, *R*, will give the outside of the mould; join the points *LA*, and *BR* will give the ends for a plumb or perpendicular joint to the plan of the stair, so the mould for this quarter will be completed.

In the same manner the other moulds for the rail will be found, by taking the heights *Zz*, *Cy*, for the second mould, and *Yy*, *Da* for the third; *xX*, 15 *w* for the fourth mould.

FIG. 3, shows the manner of drawing the plan of a rail of this kind with a pair of compasses.

Let *OA* be the radius of the conical frustum at the top of the rail, and *On* the radius of the frustum at the bottom of the rail; divide the difference *Aa*, into four equal parts; round

round the centre O , construct a square whose sides are each equal to one of the four parts of Aa , the centre O being the centre of the square $1\ 2\ 3\ 4$, and two of its sides being parallel to AO ; produce the sides of the square $1\ 2\ 3\ 4$, towards G, H, I, K ; take the radius OA , made less by half the side of the square, and on the point 1 , as a centre, describe the quadrant BC , cutting $1\ G$ at B , and $1\ H$ at C ; on 2 as a centre, with the distance $2\ C$, describe the arc CD , cutting $2\ H$ at C , and $2\ I$ at D ; on the point 3 , with the distance $3\ D$, describe the arc DE , cutting $3\ K$ at E ; lastly, on 4 , with the distance $4\ E$, describe the arc EF , cutting $1\ G$ at F , will complete the inside of the plan of the rail near enough for any practice; then if BG be the thickness of the rail, the outside of the rail G, H, I, K , will be completed by going round the centres $1\ 2\ 3\ 4$, in the same order.

FIG. 4, shows the plan of a rail for a conical well-hole to three flights of stairs.

Note. The plan of these rails are the same curve as the spiral of Archimedis.

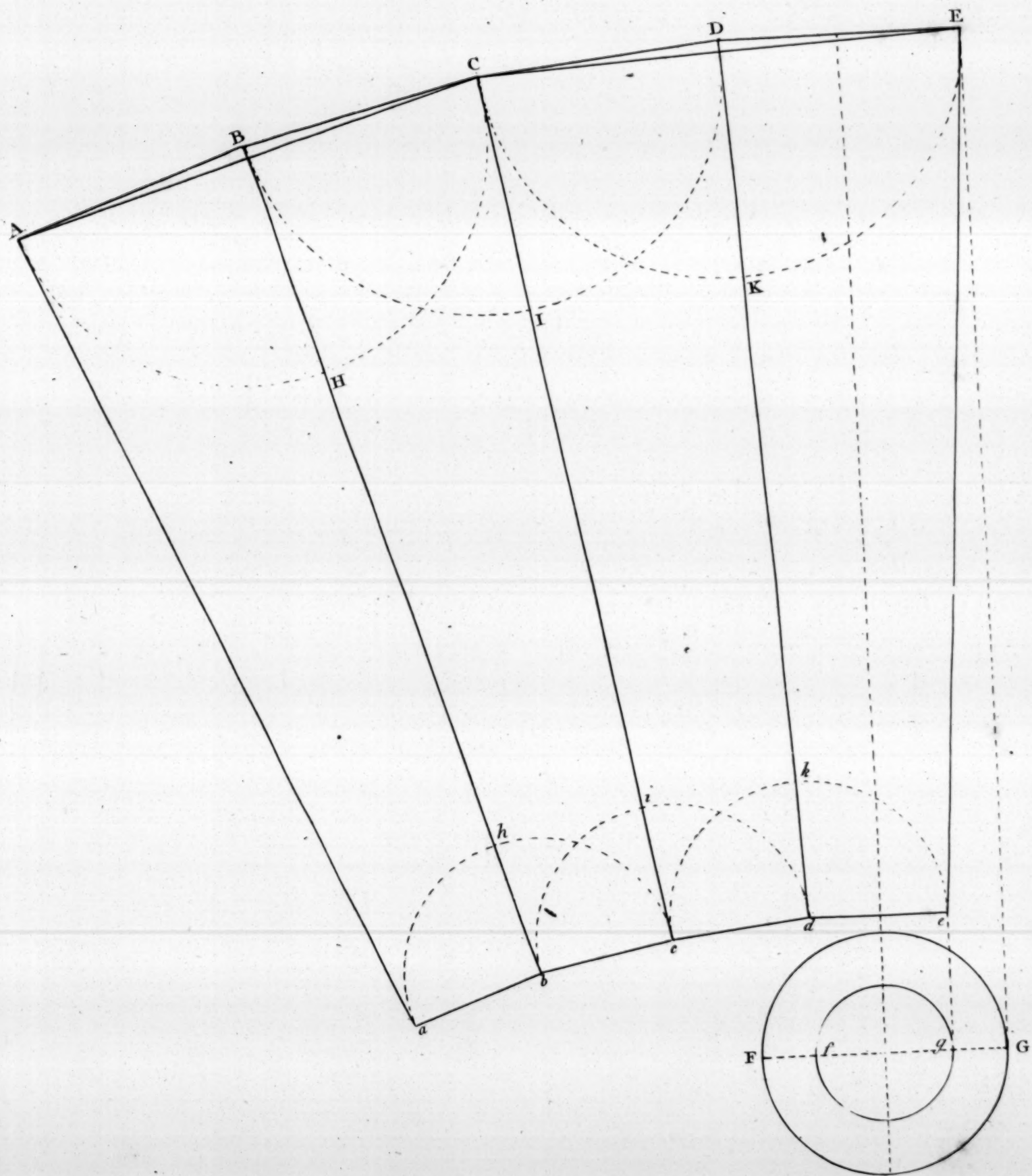
PLATE LXIII.

MOULDS.

How to find the moulds for making a hand rail in thicknesses, when the well is the frustum of a cone.

Let DE and de be the top and bottom diameters of the frustum, equal to FG and fg on the plan; and Dd, Ee , the slant sides; on D as a centre, with the distance DE , describe a circle EKC , cutting Dd at K , and DE at E ; make the arc KC equal to the arc KE , and on d , as a centre, with the distance dc describe a circle cutting Dd at k and de at e ; from k make the arc kc equal to the arc ke , through the points C and c draw the line Cc ; also through D and E , draw DE ; then on C , as a centre, with the distance CD describe an arc DIB , cutting Cc at I , and CD at D ; make the arc IB equal to the arc ID ; on c , with the distance cd , describe an arc dib , cutting Cc at i , and cd at d ; make the arc ib equal to the arc id ; join CB, cb , and Bb , and proceed in this manner as far as may be thought necessary; then the points A, B, C, D, E , and a, b, c, d, e , will be in the circumferences of circles of which the vertex of the cone is the centre; a circle may be described round any three of these points by means of a lath, as is shown in plate 58, fig. 3. This is a necessary preparation for the next plate.

PLATE







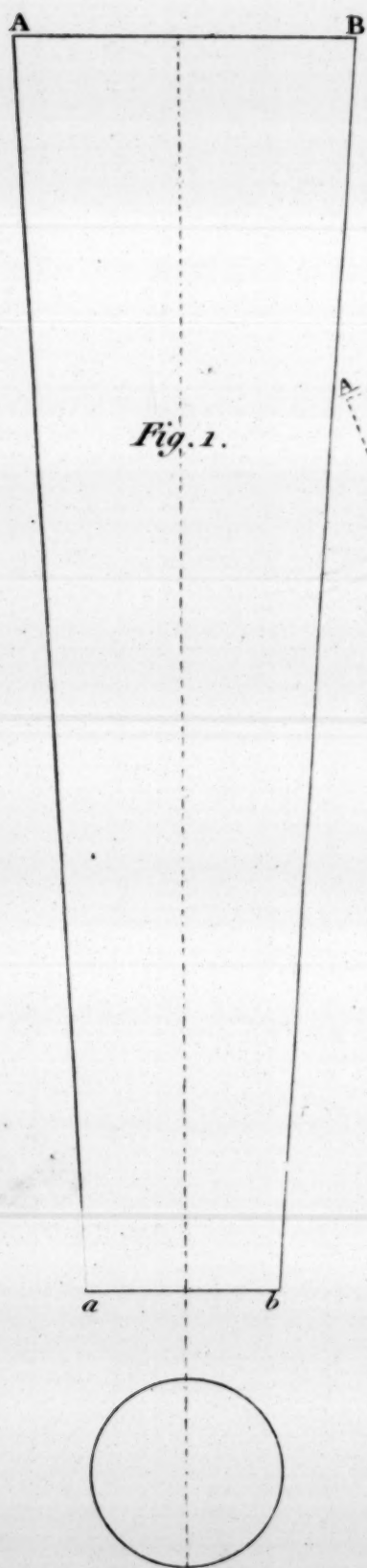
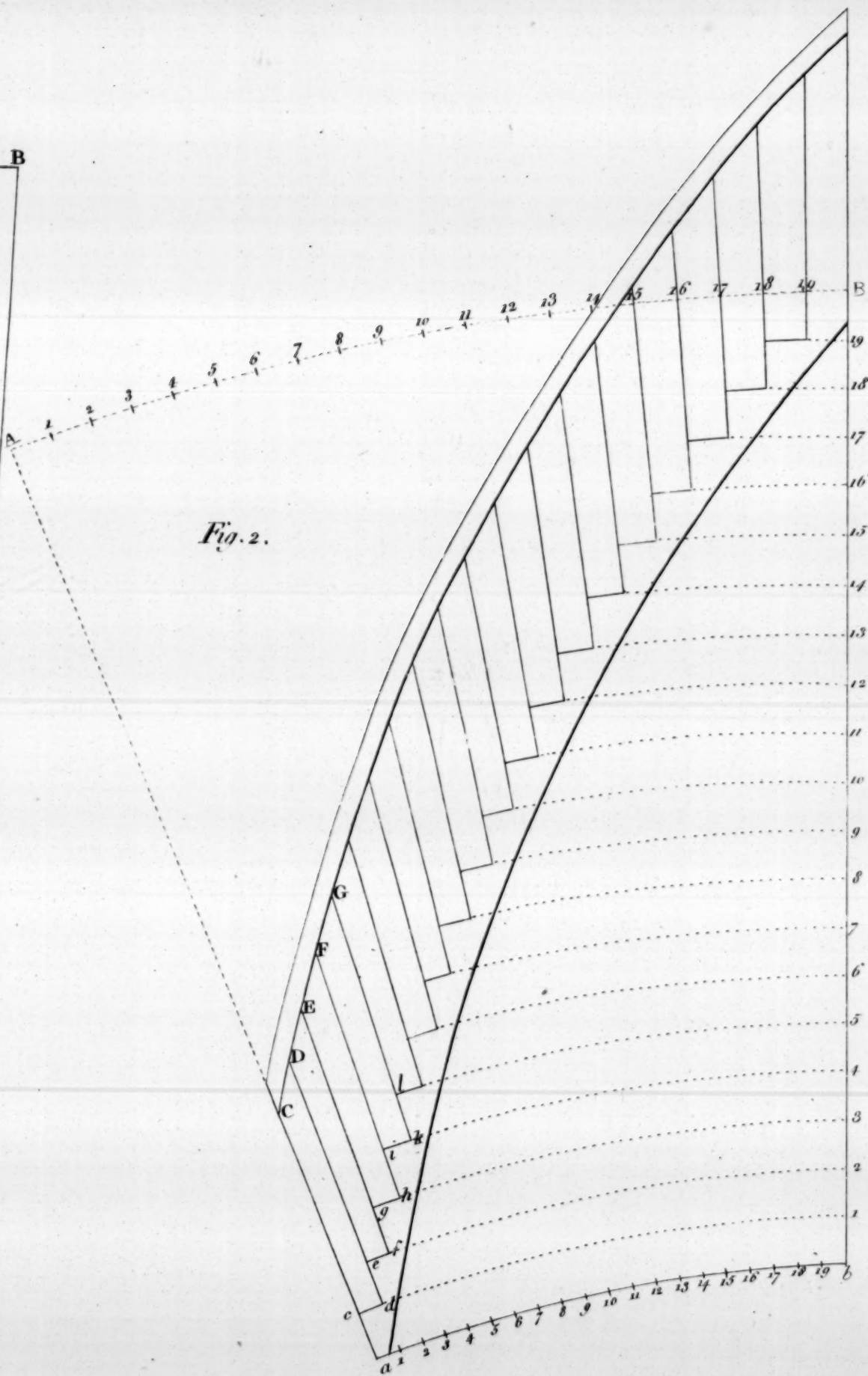


Fig. 1.

Fig. 2.





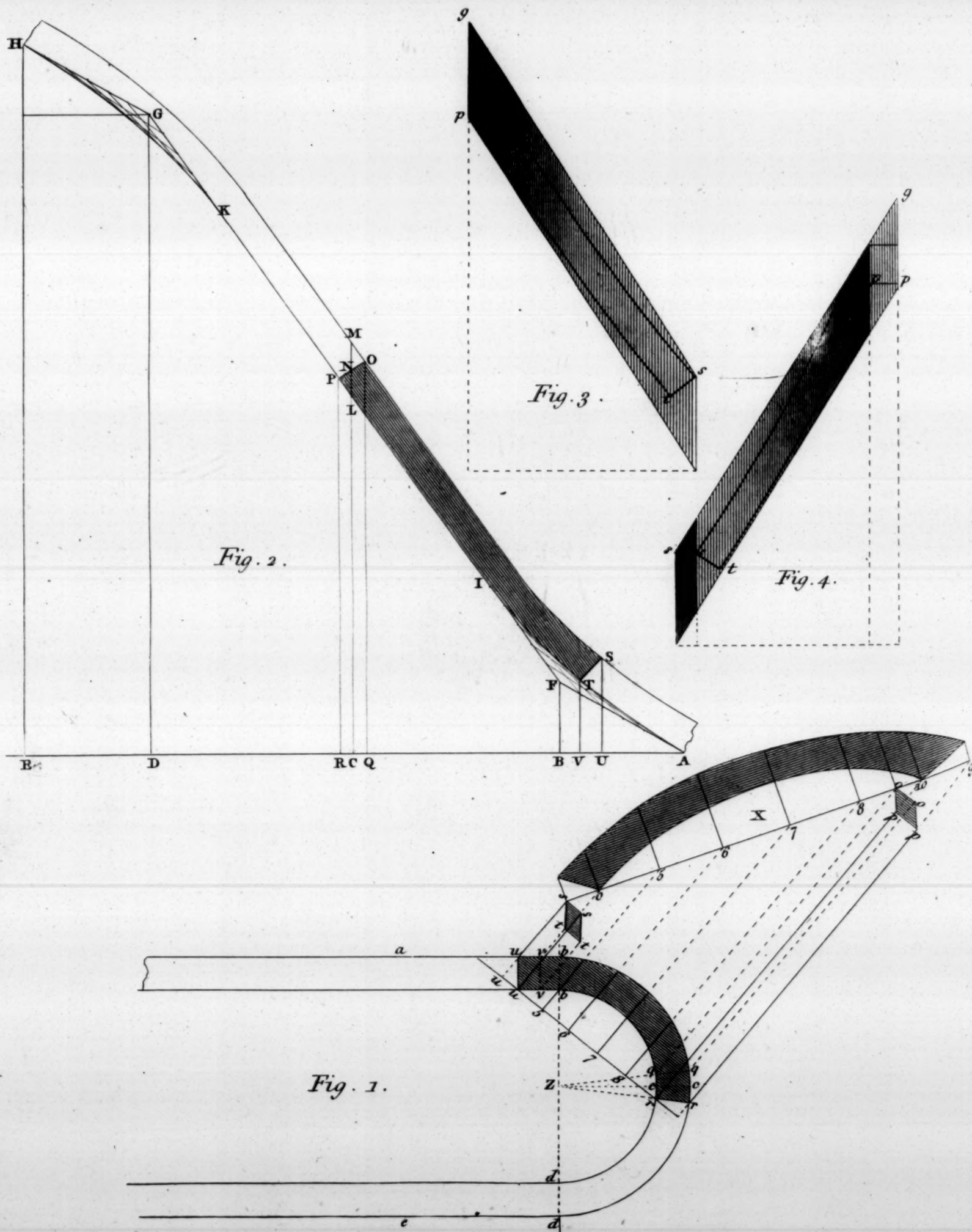


PLATE LXIV.

Let Bb be the slant side of the cone, containing twenty steps; AB and ab be two arcs found as in the last plate, by means of a lath, of which the vertex of the cone is their centre; divide aA and bB , each, into twenty parts or heights of steps, beginning at the bottom; then, with the same lath through each two corresponding points, draw circles by means of the before-mentioned lath; from B and b , make the arcs BA and ba , equal to the circumferences at the top and bottom of the frustum, *fig. 1*, whose diameters are AB and ab , and divide each of these circles into twenty equal parts, or treads, at 1, 2, 3, 4, &c. and 1, 2, 3, 4, &c. then ac will be the height of the first step, and de the height of the second; by drawing a line from 1 to 1, in the same manner fg , hi , kl , &c. will be found by drawing lines between 2 2, 3 3, 4 4, &c. until you have got to the top at B . The steps being now compleated, the rail will easily be found as follows: Draw lines cC , eD , gE , iF , kG , &c. through the points 1, 1.2, 2. 3, 3.4, 4. which will all tend to the vertex of the cone; then make all the heights cC , eD , gE , iF , kG , &c. equal to the height of the balusters, and draw a curve through all the points; C , D , E , F , G , will give the under edge of the falling mould, and a line being drawn above, parallel to, at the thickness of the rail, will give the upper edge, which will be a mould for one of the thicknesses.

PLATE LXV.

To find the moulds for making butt joints for a rail, when got out of the solid.

Let *fig. 1*, be the plan of the rail bcd , and bcd the two sides of the circular part; ab , and de , the breadths of two common steps at the beginning and end of the winders; make the whole stretch-out of the straight line $ABCDE$, *fig. 2*, equal to $abcde$, round the outside going upwards, *fig. 1*; that is, make AB , in *fig. 2*, equal to ab , *fig. 1*; the last common step in the ascent before the winders; BCD in *fig. 2*, equal to the circumference of the semi-circular part bcd , *fig. 1*, and DE , in *fig. 2*, equal to de ; on the outside, *fig. 1*, the first common step immediately after ascending the winders, draw the lines BF , DG , and EH , perpendicular to AE ; make BF equal to the height of one step; make DG one step higher than the number of winders that is in this example; suppose the circular part to contain eight winders, then DG will be equal to the height of nine steps; make EH equal to the height of ten steps; then join AF , FG , GH , and describe the parabolical parts AI , and KH , and the under edge of the falling mould will be completed; the upper edge will be formed by drawing a line parallel to it, equal to the thickness of the rail.

H

Bisect

Bisect the stretch-out of the circular part $B D$, at C ; from C draw $C M$ perpendicular to $A E$, cutting both edges of the falling mould at L and M ; bisect $L M$ at N , and through N draw $O P$ at right angles to the falling mould, cutting it at O and P ; through the points O and P , draw $O Q$ and $P R$, each perpendicular to $A E$, cutting $A E$ at Q and R , let $S T$ be the joint on the straight part; then from the points S and T , draw $S U$, and $T V$ perpendicular to $A E$, cutting it at U and V ; then take the distances $C R$ and $C Q$, in *fig. 2*, and apply them in the middle of the circular part, *fig. 1*, from c to r , and from c to q , and draw to the centre $r Z$, and $q Z$, cutting the inside of the rail at r and q ; also take the distances $B V$ and $B U$, *fig. 2*, and apply them from b to v , and from b to u , *fig. 1*; then draw $v v$, and $u u$ at right angles to the rail, cutting the other side at v and u ; then through the points u and r on the inside of the rail, *fig. 1*, draw the chord $u r$; then from all the points u, u, v, v, q, q , and r, r , draw lines $u u s, u s, v t, v t$, and $q o, \&c.$ each perpendicular to the chord line $u r$; then complete the sections of the rail $t t s s$, and $o o p p$, as are shown at the shadowed parts, and draw the chord line $s o$ to touch these sections without cutting them. Then take any number of intermediate points, as 5, 6, 7, 8, in the chord $u r$, and draw the lines 5 5, 6 6, 7 7, 8 8, perpendicular to $u r$, cutting the chord of the face mould $s o$, at the points 5, 6, 7, 8; continue the lines $u s$, and $r p$, till they cut the chord line of the face mould $s o$, at o and q ; through all the points $s, o, 5, 6, 7, 8, o, 10, 9$, draw lines perpendicular to the chord of the face mould $s o$, for ordinates, points being found in each of them corresponding to these; on the plan and lines being traced through these points, the face mould X will be completed in the usual manner.

N. B. The small letters on the sections of the face mould, and similar capital letters on the falling mould, shew corresponding places in each.

How to cut the joints.

The stuff must first be cut out by the face mould, and the joints made exactly plumb, according to the face mould, as is shown by *fig. 3* and 4.

To make this appear plain, of *fig. 3* and 4, are different views of the solid rail got out by the face mould X . *Fig. 3*, shows the top and convex side of the piece that is to make the rail; take the distance $g p$ from the chord line of the face mould down the perpendicular, *fig. 1*, and set it from g to p in *fig. 3*. Then apply the shadowed part of the falling mould at *fig. 2*, which is to correspond to the block of the rail, *fig. 3*, that is, apply the point S , the upper edge of the lower end of the falling mould at *fig. 2*, to the point s at *fig. 3*, and bend the falling mould round until the point P , the lower edge of the upper end of the falling mould, coincide with the point p ; draw a line all round by the falling mould, it will show how to cut off the ends of the rail, and will also give the upper and lower edge of the rail. *Fig. 4* shows the concave side of the piece, in order to show the ends; having similar letters of reference as before. From s , in *fig. 4*, draw $s s$ at right angles to $s b$; then cut off the end through the line $s s$, as is shown at *fig. 3*, and through the points s, t , as is shown at *fig. 4*. The upper joint will be found in the same manner, that is, by drawing the line $p p$ at right angles to $g p$, then cut

cut off the end through the line $p p$, in *fig. 4*, and through $p o$, as is shown in the other view, *fig. 3*. If great accuracy is required in squaring the rail, make an inside falling mould, which apply the under edge of the upper end to the point p in *fig. 4*, and the upper edge of the lower end of the falling mould to the point s , and draw lines above and below by the two edges of the falling mould, and it will give the form of the upper and under edges of the rail. By this method of proceeding, the workman will be enabled to cut out the stuff of a hand rail with very great accuracy.

Addition to the Description of PLATE XXIX.

For making of rule joint, *fig. 2, 3*, observe that if there is not a space about one-sixteenth of an inch between the straps, when the hinge is shut, it will be necessary that no light be seen through the joint, to work the file B on the outside, half a sixteenth further on than exactly square, to accommodate which you must take as much from the file A.

But if there is the requisite space between the straps, then the above observation does not apply, and it is better the hinge should be thus.

and all the rest of the work is done in the same manner. The first thing to be done is to draw the plan of the work, and then to cut out the pieces of wood. The next thing to be done is to join the pieces of wood together, and then to glue them. The last thing to be done is to sand the work down, and then to paint it.

PLATE XXIX

The work shown in this plate is a small table. It is made of wood, and is painted. The table has four legs, and a flat top. The legs are joined to the top by a piece of wood. The table is shown in a perspective view.

EXAMPLES

EXAMPLES

OF

ROOFS

WHICH ARE BUILT.

IN the Preface I have stated my reasons for giving these Examples; it is only necessary here for me to say, that the following are taken from my own actual measurements, viz. St. Paul's Cathedral, Islington Church, St. Martin's Church, the new roof of Covent-Garden Church, the Chapel of Greenwich-Hospital, and the Tower of the York-Buildings Water-works. The old roof of Covent-Garden Church I have been favoured with from a Gentleman's drawing, who measured it at the time of the repairs in 1795.

The roofs of Drury-Lane and Birmingham Theatres were copied, by permission, from the original drawings.

PLATE LXVI. AND LXVII.

Of the Dome of St. Paul's Cathedral, London.

A A a a A A, a dome of brick, two bricks thick, which, as it rises every five feet, has a course of excellent brick of 18 inches long, bonding through the whole thickness. This dome, it may be proper to observe, was turned upon a centre, which was laid without any standards from below to support it. Every story of the scaffolding being circular, and the ends of the ledgers meeting as so many rings, and truly wrought, it supported itself; and as it was both centering and scaffolding it remained for the use of the painter, there being a space of 12 feet between it and the dome. This machine was original of the kind.

Although the dome wants no butment, yet, for greater caution, it is hooped with iron in this manner: a channel is cut in the bandage of Portland stone, in which is laid a double chain of iron, strongly linked together at every ten feet, and the whole filled up with lead.

This dome was afterwards painted in a most beautiful style by the celebrated *Sir James Thornhill*.

B B b b B B, is a cone built with bricks, one foot six inches in thickness, and is also plaistered and painted; part of this cone may be seen from the flooring of the church through the opening at *a a*, the top of the interior dome.

The timber work is well supported by the brick cone *B B b*; the horizontal or hammer beams *C C*, *D D*, *E E*, *F F*, being curiously tied into the corbels *G*, *H*, *I*, *K*, with iron cramps, which are well bedded into the corbels with lead, and bolted to the hammer beams.

Between the trusses of the roof is carried the stairs which lead to the Golden Gallery at the top of the dome.

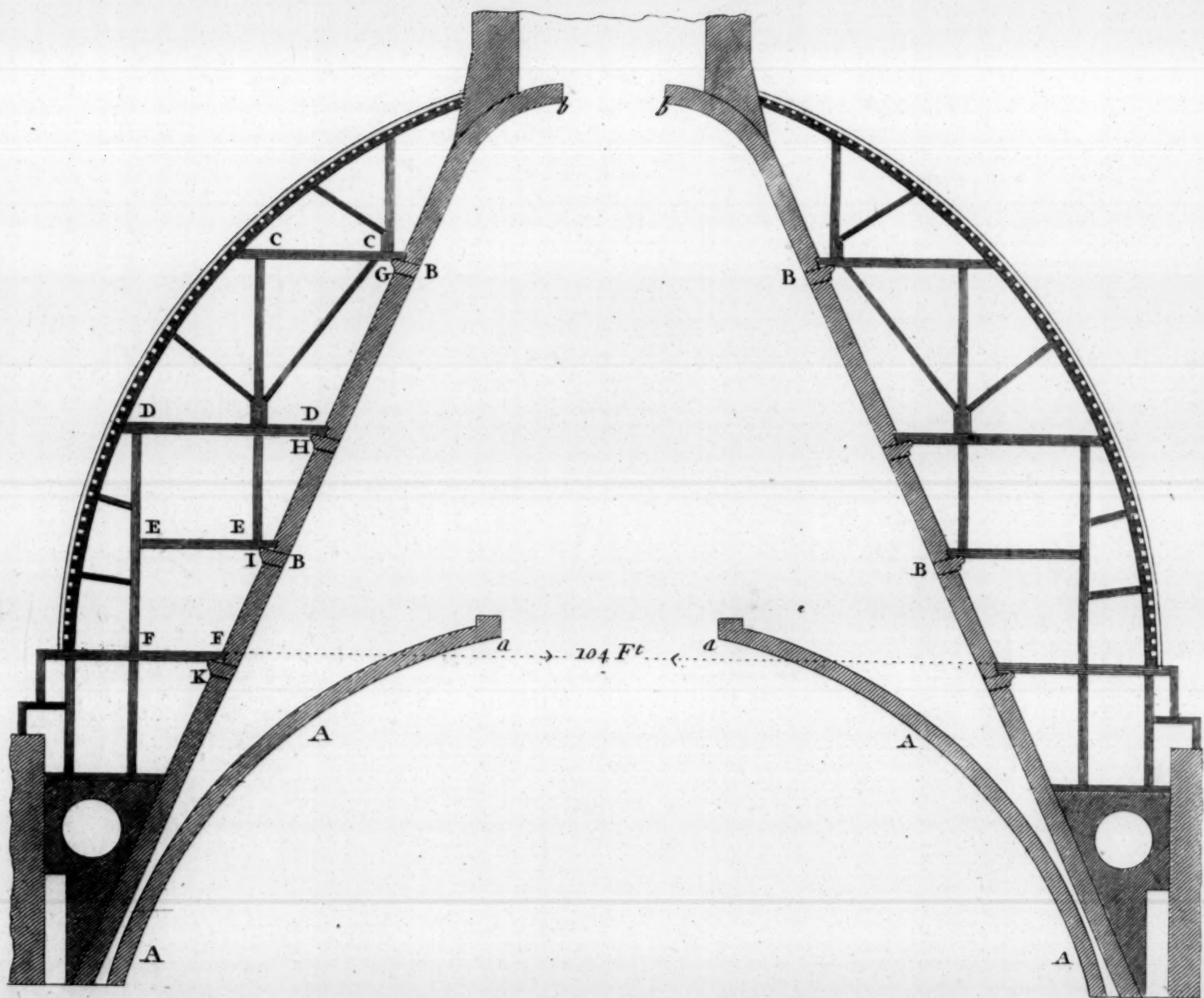
The dome is boarded from the base upwards, and therefore the ribs are fixed horizontal at near distances to each other, in the same manner as is shown in my example of a domical roof, Plate XIII. of this work, where the sides of all the ribs stand in planes tending to the centre of the dome. The scantling of the curve rib of the truss, is 10 inches by 11½ at the bottom, and 6 inches by 6 at the top.

The sides of the dome are segments of circles, the centres of which are marked in the plate, and which, if continued, would meet at the top, and form a pointed arch.

On the top of the dome is built a cupola of Portland stone, which is twenty-one feet diameter, and near sixty-four feet high, supported by the cone, and by the timber work of the trusses.

The construction of this dome is an admirable example of the skill and great mathematical knowledge of *Sir Christopher Wren*.

PLATE



5 10 20 30 40 Feet



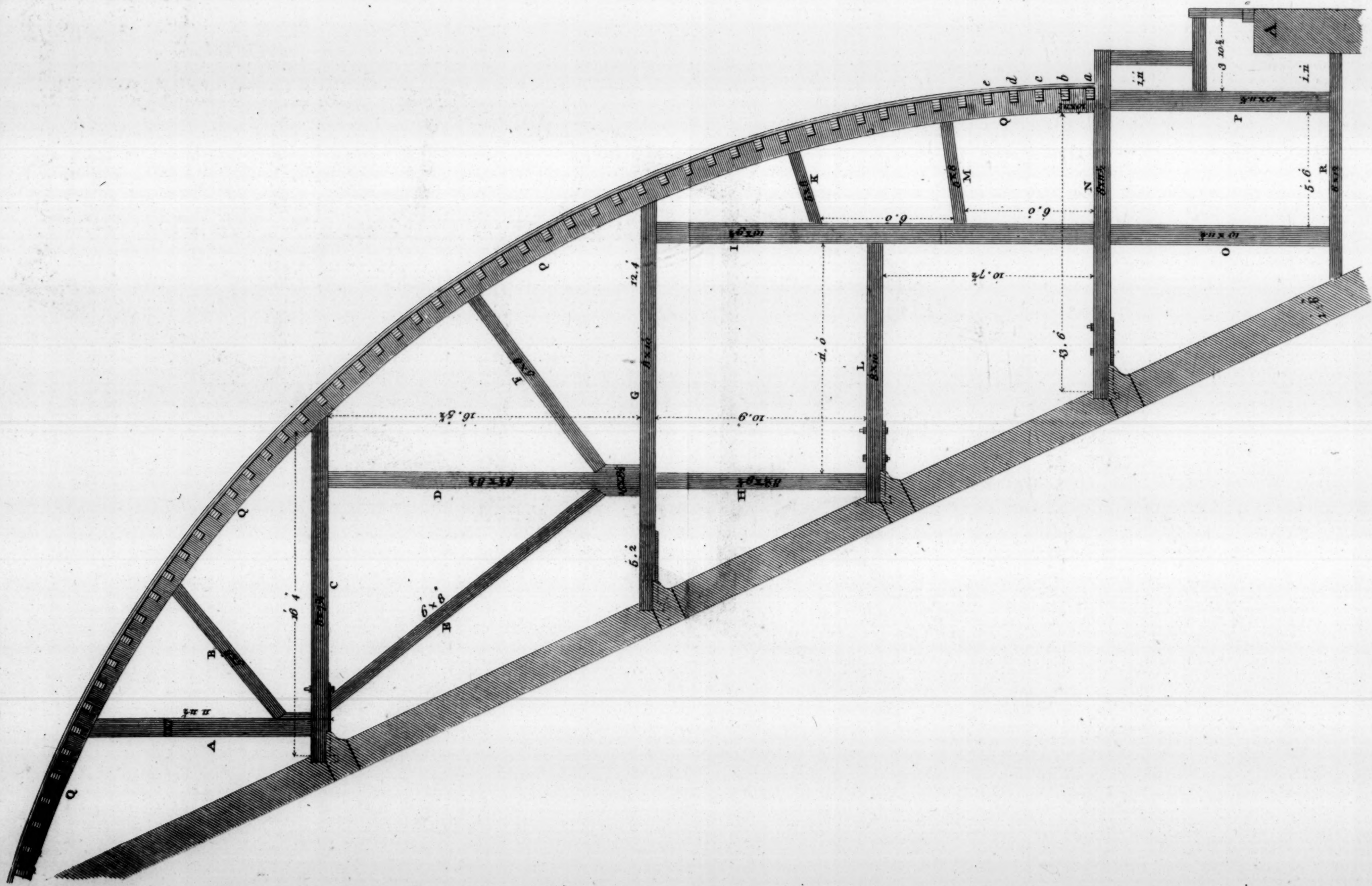




PLATE LXVII.

A truss of the dome to a larger scale, showing the manner in which the iron cramps are fixed to the corbels and bolted to the hammer beams. The horizontal bars, *a*, *b*, *c*, *d*, are about four inches square, and about the same in number as are shown in the plate.

A a, part of the stone work which supports the steps or breaks, immediately under the curve of the dome.

Scantling of the timbers.

<i>A</i> Post	—	—	7 in. by 7	<i>M</i> Strut	—	—	5 in. by 8
<i>B</i> Strut	—	—	5 in. by 8	<i>N</i> Hammer beam	—	—	8 in. by 11½
<i>C</i> Hammer beam	—	—	8 in. by 7¾	<i>O</i> Post	—	—	10 in. by 11½
<i>D</i> Post	—	—	8½ in. by 8½	<i>P</i> Post supporting the curve	—	—	10 in. by 11½
and 15 by 8½ at bottom.				rib of the dome	—	—	10 in. by 11½
<i>E</i> Brace	—	—	6 in. by 8	Curve rib of the	—	—	10 in. by 11½
<i>F</i> Strut	—	—	5 in. by 8	dome	—	—	10 in. by 11½
<i>G</i> Hammer beam	—	—	8 in. by 10	at bottom, and 6 in. by 6	—	—	at top.
<i>H</i> Post	—	—	8¾ in. by 9½	<i>a</i> , <i>b</i> , <i>c</i> , <i>d</i> , &c. small hori-	—	—	4 in. by 4
<i>I</i> Post	—	—	10 in. by 9½	zontal rafters	—	—	8 in. by 12
<i>K</i> Strut	—	—	5 in. by 8	<i>R</i> Wall plate	—	—	8 in. by 12
<i>L</i> Hammer beam	—	—	8 in. by 10				

The diameter of the dome is 104 feet, and in the circumference there are 32 trusses. It may be observed that the scantling of none of the timbers in this dome is so great, as in many churches.

PLATE LXVIII.

Of the old and new Roofs of St. Paul's Church, Covent Garden.

The beautiful portico of this Church is of the Tuscan order, and is executed according to the rules of Vitruvius, who says, that the mutules or cantilivers of the cornice ought to project a quarter of the height of the columns, which requires the roof to have a peculiar construction, which is shewn in these trusses.

FIG. 1, the roof to the Church, as executed by Inigo Jones, and which was consumed by the unfortunate fire in 1795.

PLATE

PLATE LXVIII.

FIG. 1. *The old roof.* Scantlings.

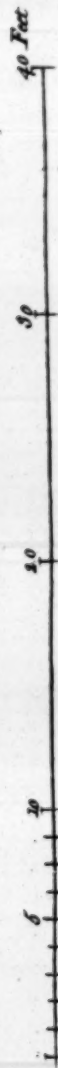
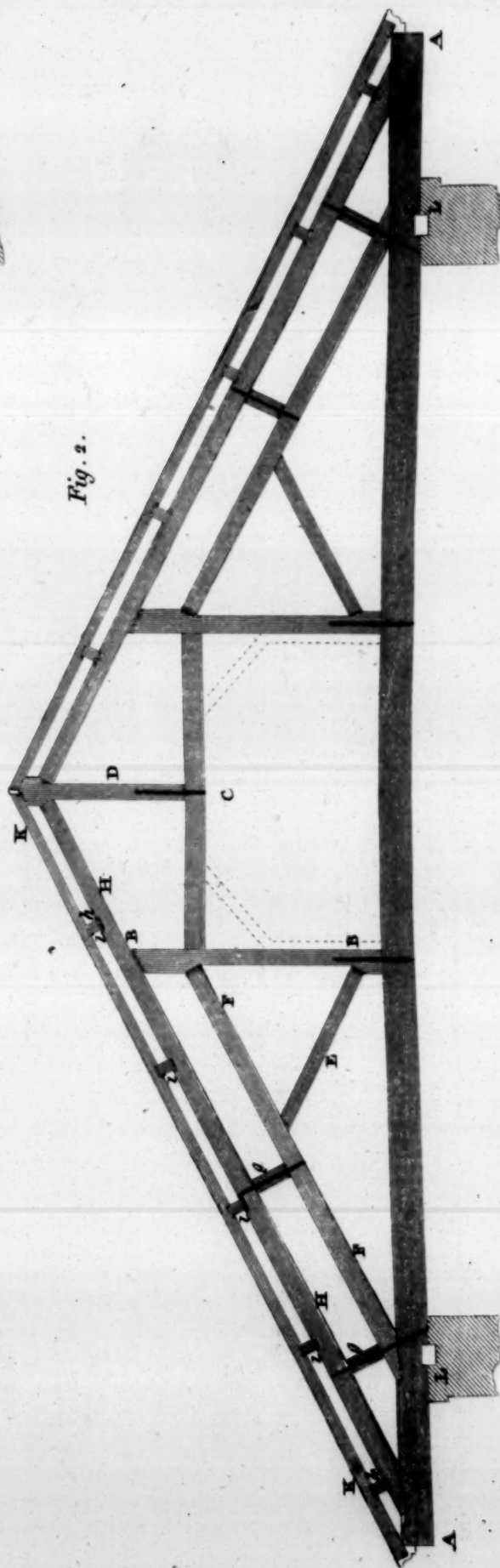
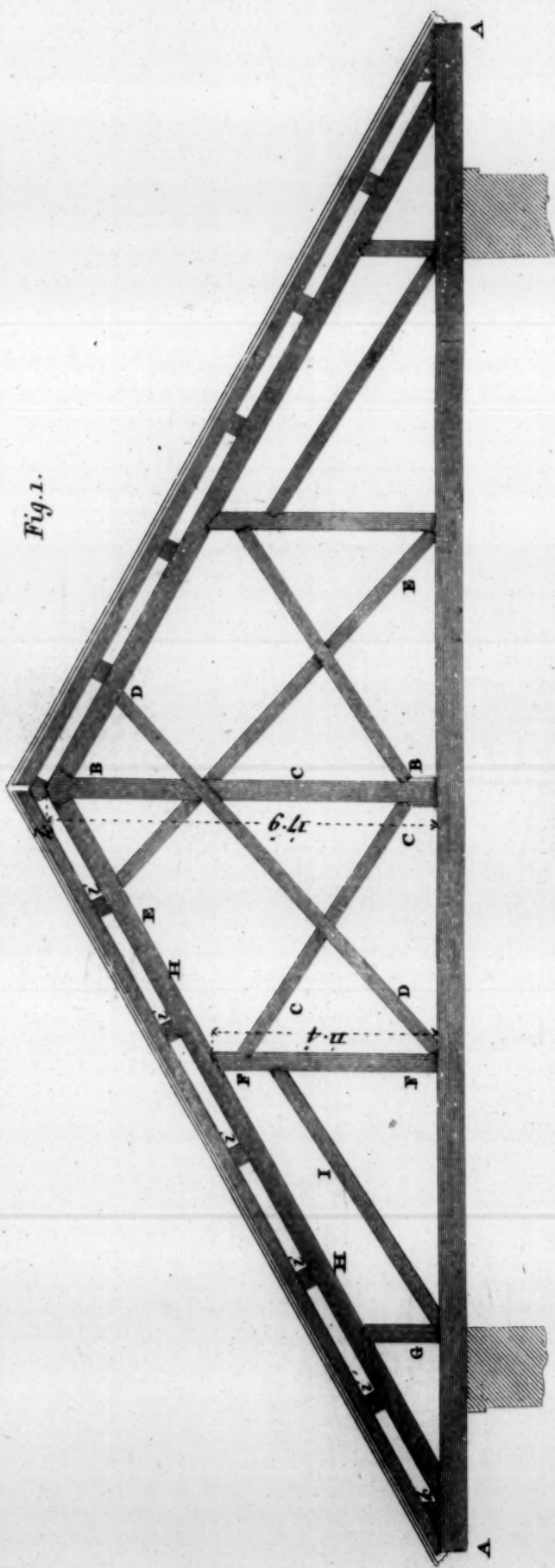
<i>A A</i> , the tie beam projecting over each wall about seven feet, which is the projecture of the mutules, being in length about 72 feet, and 50 feet 2 inches in the clear of the walls	—	—	16 in. by 12
<i>B B</i> , the king post	—	—	12 in. square.
<i>C C</i> , <i>D D</i> , <i>E E</i> , braces halved into each other, and also into the king post <i>B B</i>	—	—	12 in. by 8
<i>F F</i> , one of the queen posts	—	—	12 in. by 12
<i>G</i> , one of the studs	—	—	10 in. by 10
<i>H H</i> , one of the principal rafters	—	—	12 in. by 10
<i>I</i> , one of the principal braces	—	—	12 in. by 8
<i>i i i i</i> , purlines	—	—	12 in. by 10
<i>k k</i> , common rafter	—	—	6 in. by 4
The distance between the trusses about 10 feet 6 inches	—	—	

FIG. 2. *Truss for the new roof.* Scantlings.

<i>A A</i> , the tie beam, which cambers 6 inches on the clear of the church; the length of the beam being the same as in the old truss	—	—	16 in. by 12
<i>B B</i> , one of the queen posts (in the small part)	—	—	8½ in. square.
<i>C</i> , collar beam	—	—	10 in. by 8
<i>D</i> , king post (14 in. at the jogle)	—	—	8½ in. square.
<i>E</i> , brace	—	—	8 in. by 7½
<i>F F</i> , one of the principal braces, or an auxiliary to the principal rafter in order to strain the beam <i>A A</i> , and keep it from being bent over the walls by the weight of the roof (at top 8½ in. square)	—	at bottom	10 in. by 8½
<i>g g</i> , studs on one side of the roof in order to strengthen the bearing of the principal rafter	—	—	8 in. square.
<i>H H</i> , the principal rafter supported by the studs <i>g g</i> , queen post <i>B B</i> , and king post <i>D</i> (at top 8½ square)	—	at bottom	10 in. by 8½
<i>i, i</i> , the purlines on one side, supporting the small rafter <i>K K</i>	—	—	9 in. by 6½
<i>K K</i> , the small rafters	—	—	6 in. by 3½
<i>L L</i> , wall plates	—	—	12 in. by 10

The dotted lines in the middle compartment shows the manner in which this roof is framed under the cupola; the distance of the truss is about 10 feet 6 inches, as in the old roof.

At



London Published July 1.1796 by I & J. Taylor 56 High Holborn.





Fig. 1.

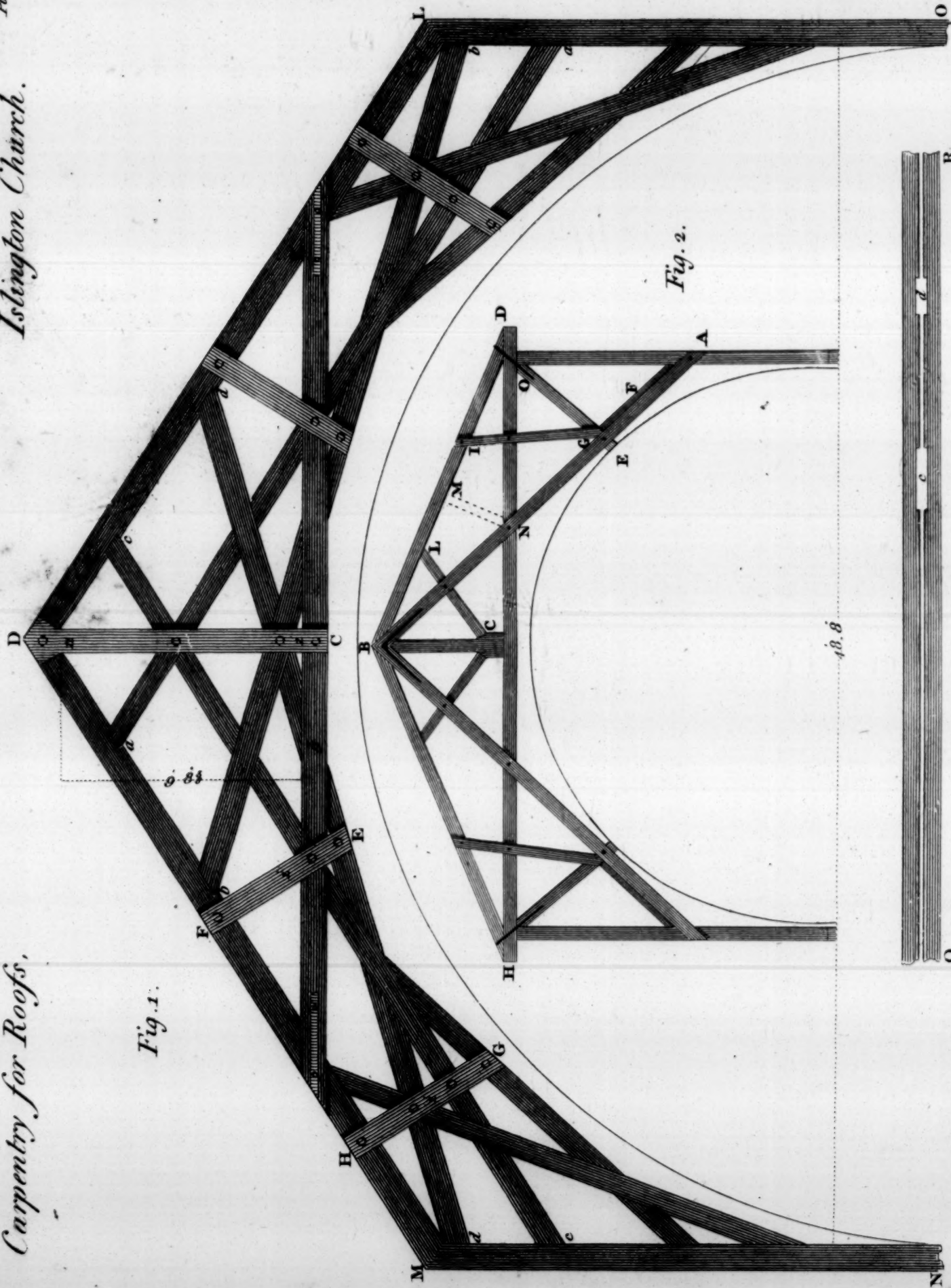


Fig. 2.

At first sight one would be led to think the timbers of the old roof are placed so as to make it very strong; but the want of proper butments, or joggles, at the bottom of the queen post, together with the frequent cutting or halving the pieces together, render it altogether very infirm, and I think much inferior to the modern roof, *fig. 2*; where every timber performs its proper office, in strengthening the roof, and in resisting the action of the wind, the weight of snow, &c. It must also be observed in favour of the modern improvements in carpentry, that a truss of the old roof contains about 273 solid feet of timber, whereas the new roof contains only about 198 feet in each truss.

The present roof was put up in 1796. Mr. Hardwick, Architect. Mr. Wapshott, Carpenter.

PLATE LXIX.

Of the roof of Islington Church.

The span of this building is forty-eight feet eight inches, within the walls; the length of the beam *IK*, is thirty-one feet three inches from the inside of one rafter to the inside of the other, which is in two thicknesses, as is shown by *fig. 2*; *c* and *d* represents the space cut out to receive the braces.

The braces *aa*, *bb*, *cc*, *dd*, are halved into each other, and are $11\frac{1}{2}$ inches broad, and seven inches thick; the king post *CD*, and the pieces *EF* and *GH*, are in two thicknesses, each piece being let in on each side of the truss into the braces, leaving a small space between them, and are all bolted together at the intersection of the braces.

The pieces *CD*, *EF*, *GH*, are each 1 foot broad; the thicknesses, together with the space between them, is one foot four inches; the distance between the trusses is 12 feet.

I should be cautious of using this kind of construction, viz. coveing the ceiling so much into the roof. Had the collar beam *IK*, been placed as low as *ML*, so as to have taken the whole span to the walls, the truss would have been more safe, and have taken less timber.

This roof was built about the year 1752; Mr. Dowbiggin, Architect, Mr. Stimson, Carpenter.

The construction of this roof is ingenious but complicated. It takes a great quantity of timbers, and the frequent intersection and halving of which is very objectionable. The timbers are too much parallel to each other, producing only quadrilateral forms, which are always liable to revolve at the angles; whereas the strongest possible construction for a roof must be sought in a triangle; and the timbers so placed, or a roof constructed on such principles, that is, with fewest quadrilaterals, will certainly be the strongest possible: With these considerations and maxims, and with due respect to the roof before us, I have shewn an example, *fig. 2*, suited to a similar purpose, and which must be considered as evidently stronger, and as taking much less timber.

FIG. 2. This truss is constructed so as to have one, two, or three purlines between the principal rafters, as circumstances may require: if only one purline is required, the proper place will be at *M*, in the middle of the rafter, with the butment at *N*, intersecting the principal brace and the tie beam. In this case the braces *G O*, *G I*, *C L*, may be omitted, which will render the truss more simple, and yet strong enough.

If two purlines are used, they of course will be placed over the braces *I* and *L*.

If three purlines are requisite, the rafter *D B*, ought to be divided into four equal parts and the braces *I*, *M*, *L*, should then be immediately under the purlines; thus every cross strain will be thrown off the timbers, and every other strain which they receive laterally, will be from their own weight only; wherefore the timbers may be very slight and yet sufficiently strong.

The brace *A B* is double, bolted together at *A*, and strongly united by an iron strap to the other brace at the point *B*, where also they are bolted together through the head of the king post: The rafters *D B*, and *B H*, may be strongly united by an iron strap over their tops.

The brace *C L* runs between the double brace *A B*, to which it is bolted at the intersection. The piece *E O* is fastened to the principal rafter and the tie beam by an iron strap, which strongly unites the three together. The brace *G I* is double, one half on each side the brace *E O*, the tie-beam, and the rafter, to each of which it is bolted at the several intersections. The butment of this brace is secured by the straining-piece *F*.

The pitch of this roof may be very low, even less than that of *fig. 1*, and yet be sufficiently strong: by so low a pitch, the beauty of the building will be increased; indeed it may with propriety be adapted to the proportion of a pediment to a portico, if required.

PLATE LXX.

Of the roof of St. Martin's Church.

FIG. 1, the whole truss entire.

FIG. 2, half of the same to a larger scale; shewing the scantlings, lengths and bearings of the timbers.

The breadth of this building, within the walls, is about sixty-nine feet; the breadth of the side ailes, reckoning from the centre of the columns to the walls is nearly fourteen feet five inches and a half; the breadth of the middle ailes, from centre to centre of the columns is about thirty-nine feet eleven inches. The form and manner of framing this roof, according to the extent and height, is judicious; but the scantling of the timbers is much more than sufficient to resist the weight of the covering, force of the wind, &c. The brace *A B*, *fig. 2*, might have been omitted; it answers no purpose to the strength of the roof, as the upright post, which it seemingly supports, is upheld by the column, which will prevent it from descending; this roof is well and sufficiently braced throughout, so that there is no danger of swerving either on one side or the other.

The church was built about the year 1721. Mr. John Gibbs, Architect.

Scantlings.

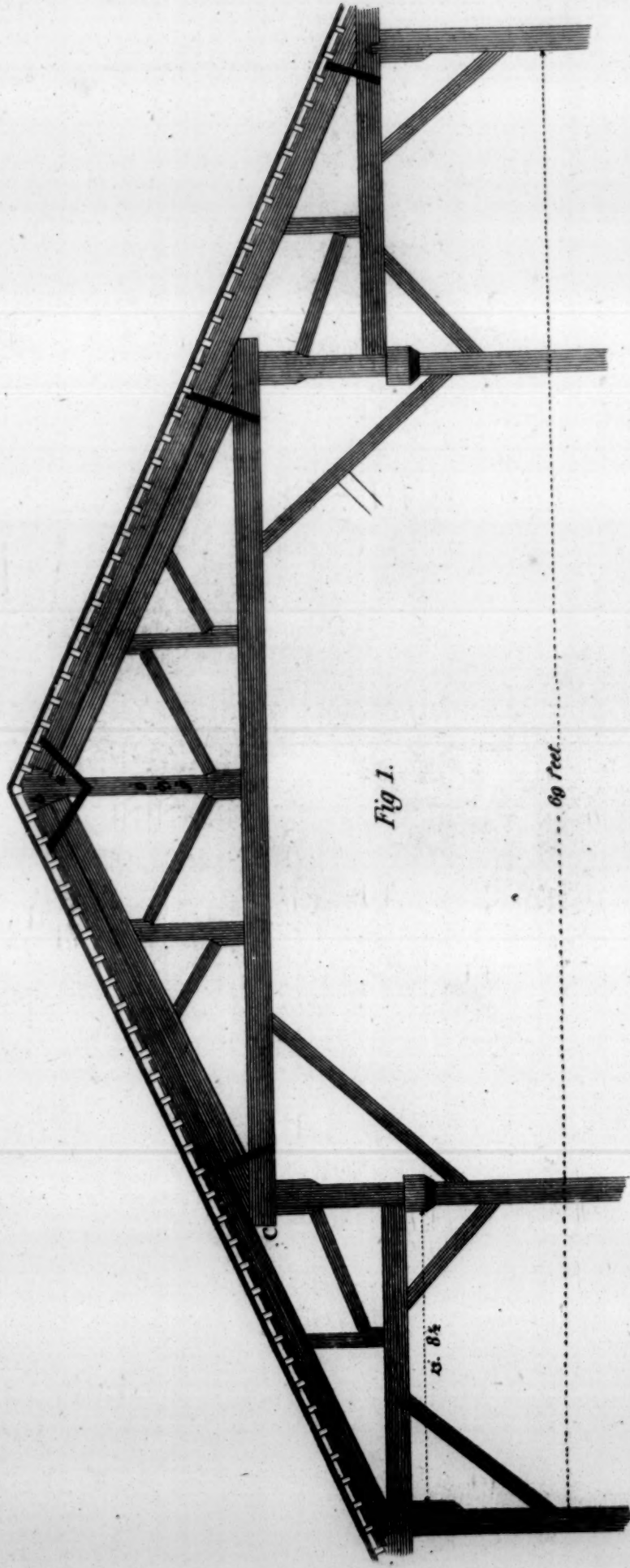


Fig. 1.

60 feet

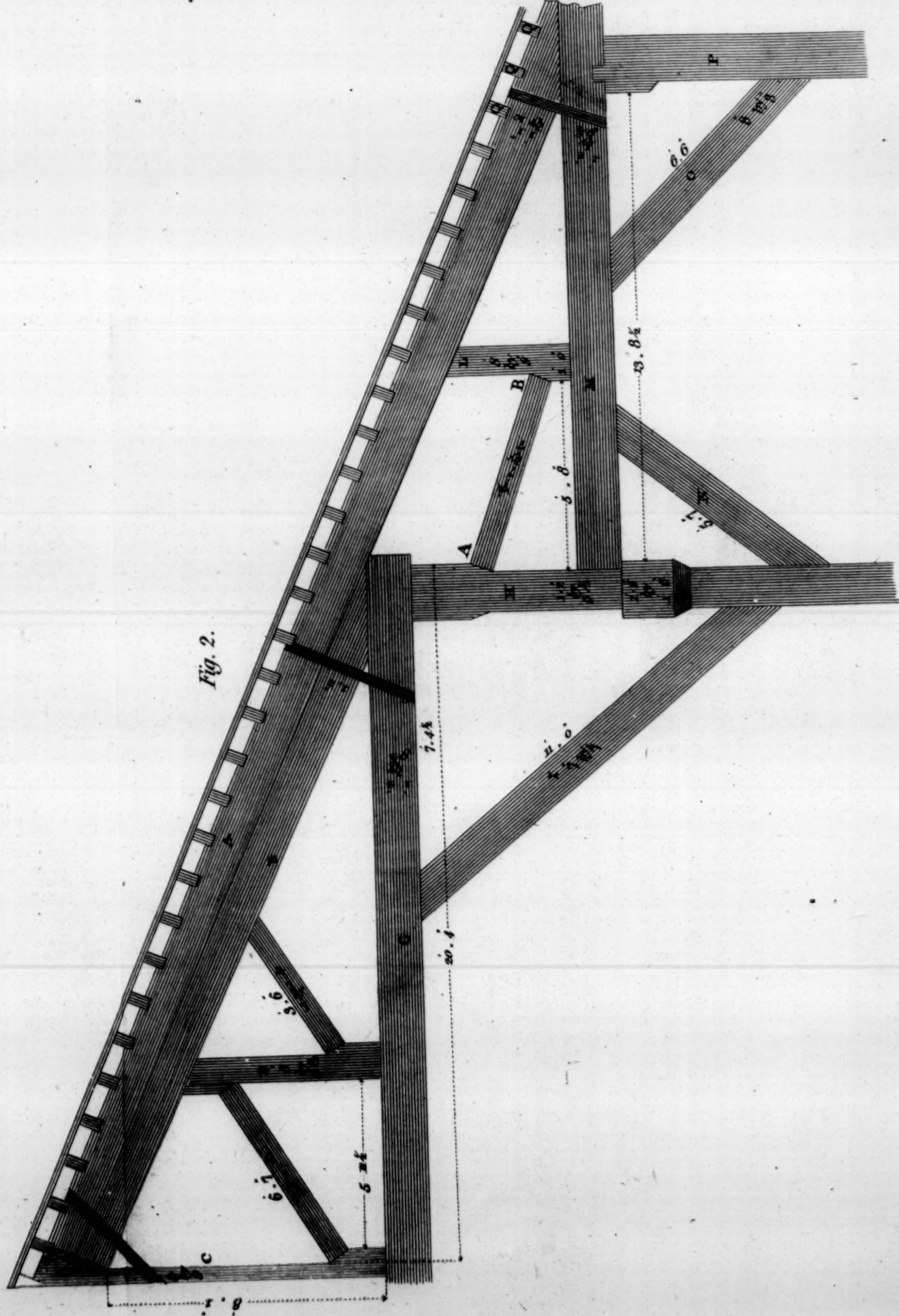
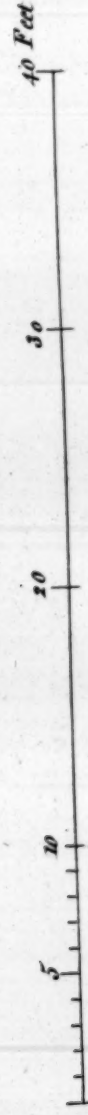


Fig. 2.





Fig. 1.

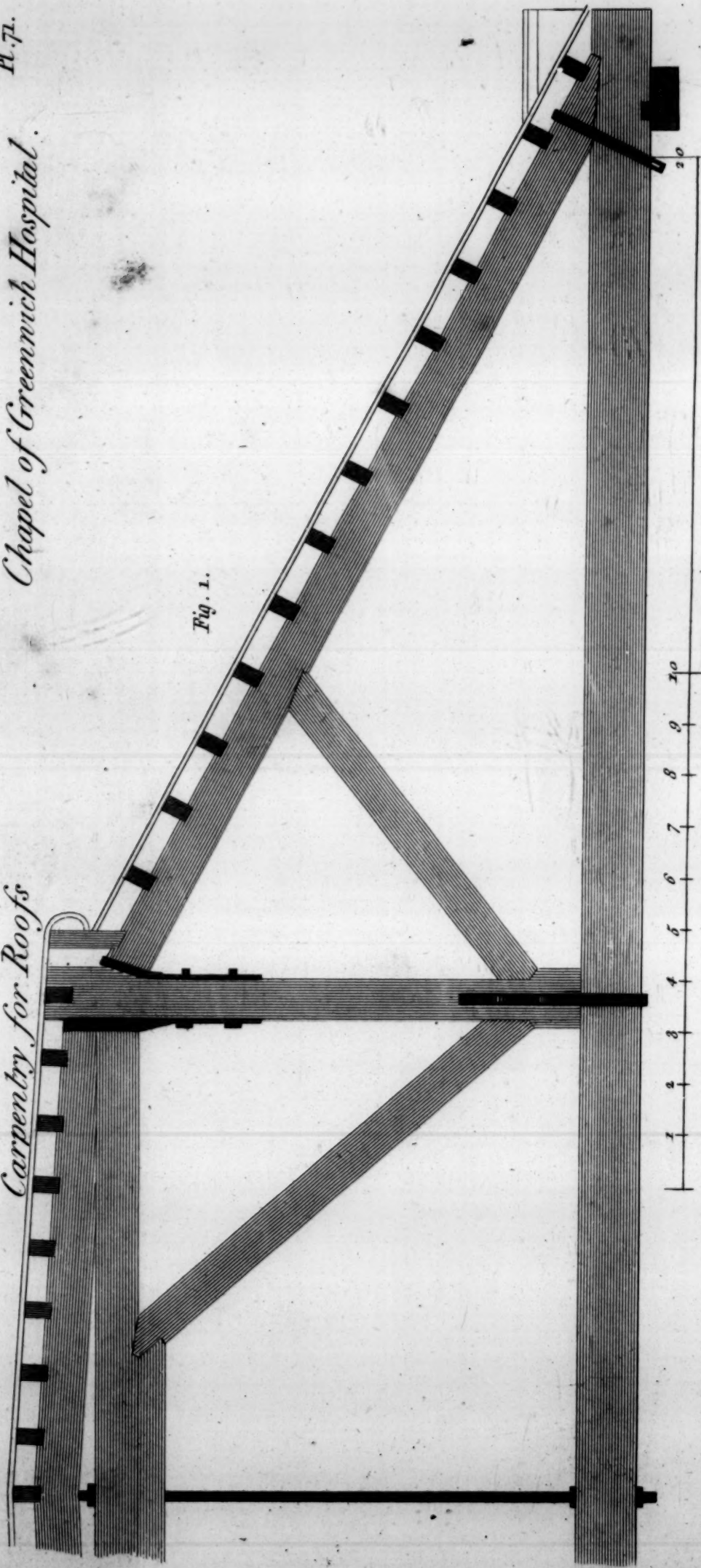
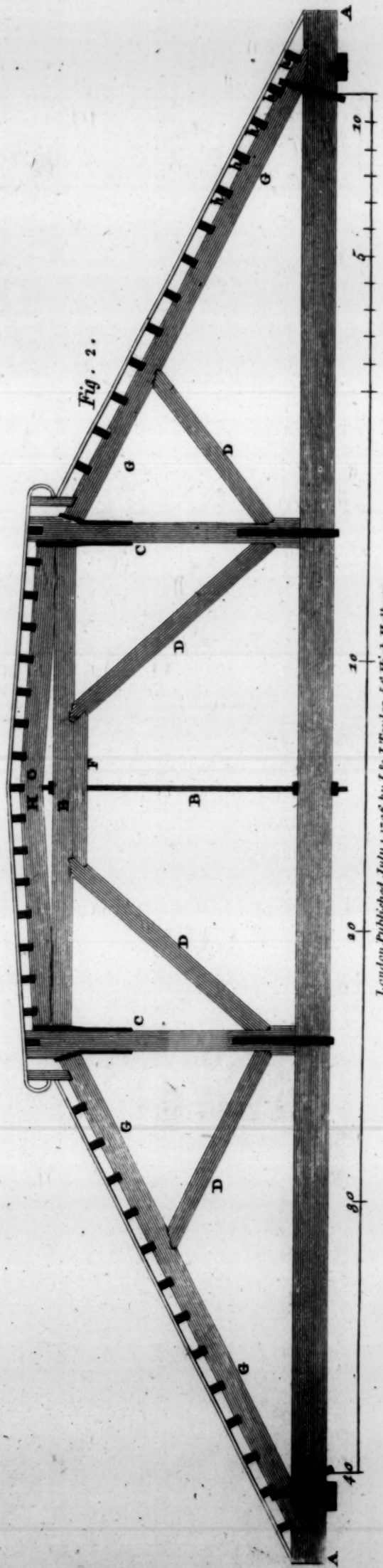


Fig. 2.



Scantlings.

<i>A</i> , principal rafter	-	13 in. by 10	<i>H</i> , post over the column	-	14 in. by 9 $\frac{1}{2}$
at bottom, and 11 by 10 at top.			<i>I</i> , brace	-	7 in. by 7
<i>B</i> , principal brace	-	14 in. by 10	<i>K</i> , brace	-	7 in. by 7
at bottom, and 11 by 10 at top.			<i>L</i> , post	-	8 in. by 9
<i>C</i> , king post	-	9 in. by 9	<i>M</i> , hammer beam	-	14 in. by 9 $\frac{1}{2}$
<i>D</i> , strut	-	7 in. by 7 $\frac{1}{2}$	<i>N</i> , brace	-	8 in. by 8
<i>E</i> , queen post	-	8 in. by 9 $\frac{1}{2}$	<i>O</i> , brace	-	8 in. by 8
<i>F</i> , strut	-	7 in. by 7	<i>P</i> , post in the wall		
<i>G</i> , collar beam	-	14 in. by 9 $\frac{1}{2}$	<i>Q, Q, Q</i> , horizontal rafters		4 in. by 6

PLATE LXXI.

Of the Roof of the Chapel of the Royal Hospital at Greenwich.

After the fire at the Hospital in 1779, which did considerable damage to the Chapel and to the wing, it became necessary nearly to rebuild the whole of the Chapel, Mr. James Stuart being then surveyor; under his eye and care it received its present beautiful decorations. The roof, Pl. 71, was constructed by Mr. Samuel Wyatt, about 1785.

The roof is flat on the top, and the construction is perhaps as strong and simple as could be contrived for a platform; the king post is of iron, and the joints are well secured by iron straps. It extends 51 feet in the clear and is a good example, materially varying from the general form of roofs.

Scantlings.

<i>A A</i> , the tie beam, the whole length			<i>E</i> , collar beam	-	10 in. by 7
is 57 feet, and the clear within			<i>F</i> , straining piece	-	6 in. by 7
the walls of the chapel is 51			<i>G G, G G</i> , the principal rafters		10 in. by 7
feet	-	14 in. by 12	<i>h, h, h, h, &c.</i> common rafters lay-		
<i>B</i> , an iron king post	-	2 in. square	ing in a horizontal direction		4 in. by 6
<i>C, C</i> , queen posts	-	9 in. by 12	<i>H</i> , a camber beam supporting the		
<i>D, D, D, D</i> , braces	-	9 in. by 7	platform	-	9 in. by 7

The distance between the trusses is about 7 feet.

PLATE LXXII.

Of the Roof of Drury-Lane Theatre.

This roof has certainly great merit, the construction is simple, and the accommodations the most ample possible. By dividing the breadth of the building into three parts the roof is kept low, and the scantling of the timbers is much reduced. The trusses are 15 feet apart, and 80 feet $3\frac{1}{2}$ inches span in the clear; the roof is about 200 feet long. Very ample accommodations for the Carpenters and Painters are obtained in the middle space which is 32 feet wide: the sides are divided into dressing rooms, store rooms, &c. the ceilings of which are flat.

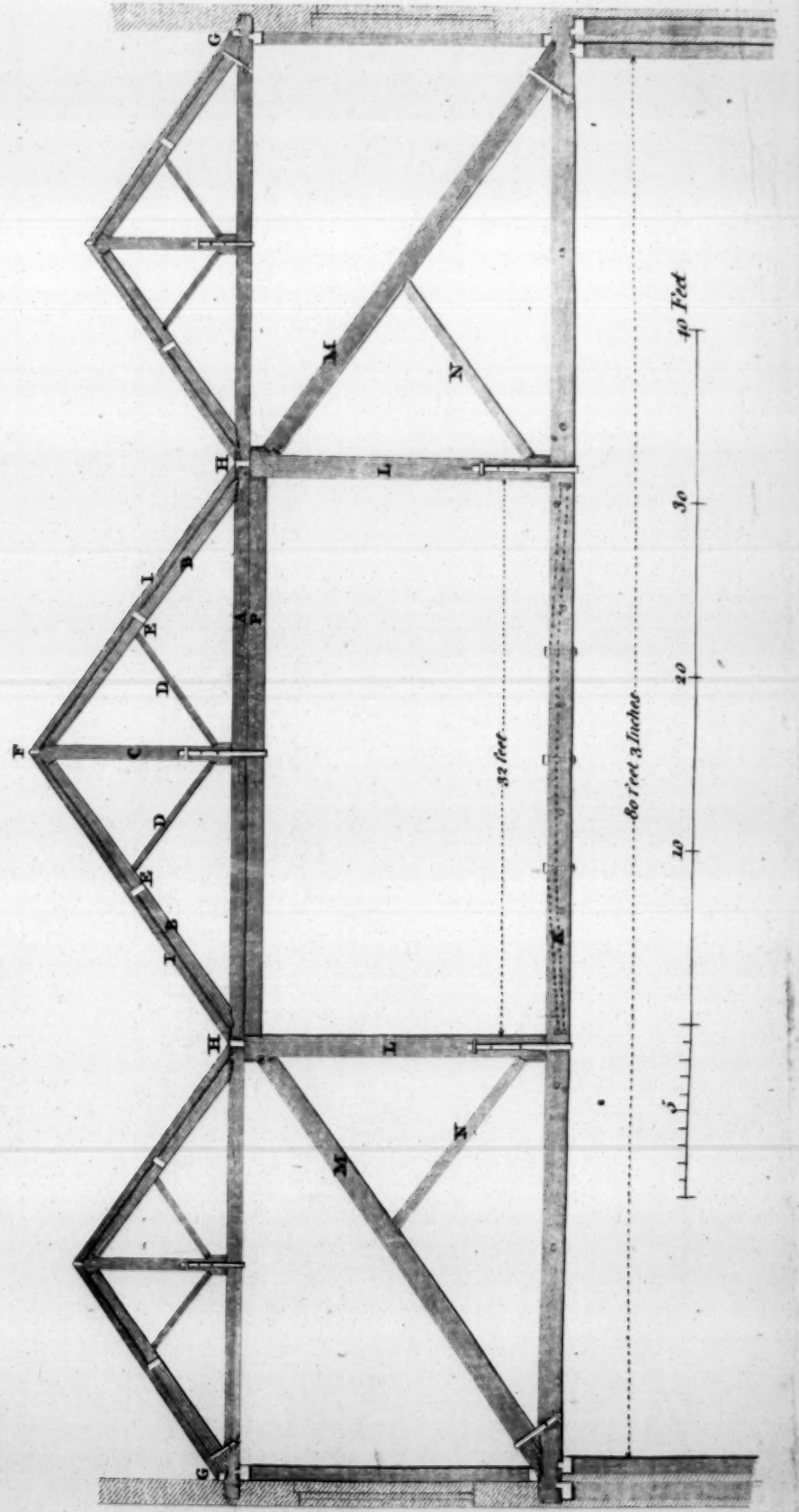
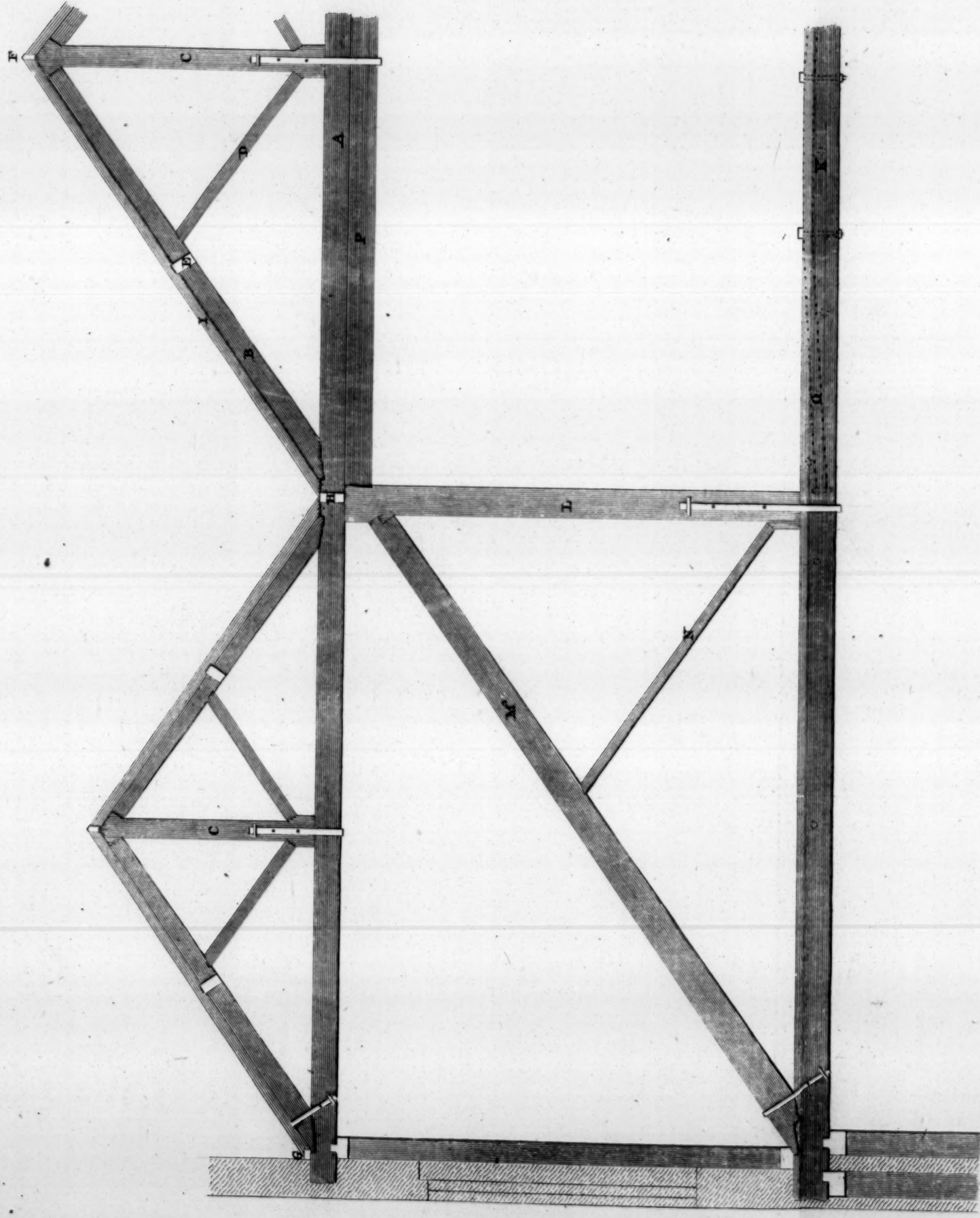
This roof was built in 1793, Mr. Henry Holland, Architect; Mr. Edward Grey Saunders, Carpenter.

The figures shew a truss entire, and half of a truss to a larger scale.

Scantlings, &c.

<i>A</i> , beams	-	-	10 in. by 7	<i>I</i> , common rafters	-	5 in. by 4 and $2\frac{1}{2}$
<i>B</i> , principal rafters	-	-	7 in. thick	<i>K</i> , beams	-	15 in. by 12
<i>C</i> , king posts	-	-	12 in. by 7	<i>L</i> , posts	-	15 in. by 12
<i>D</i> , struts	-	-	5 in. by 7	<i>M</i> , principal braces	-	14 in. by 12 and 12
<i>E</i> , purlines	-	-	9 in. by 5	<i>N</i> , struts	-	8 in. by 12
<i>F</i> , ridges	-	-	$1\frac{1}{2}$ in. thick	<i>O</i> , oak trusses to the middle	-	
<i>G</i> , pole plates	-	-	5 in. by 5	bearing of beams	-	$5\frac{1}{2}$ in. by $4\frac{1}{2}$
<i>H</i> , gutter plates framed into	-	-		<i>P</i> , straining beams	-	12 in. by 12
beams	-	-	12 in. by 6			

PLATE





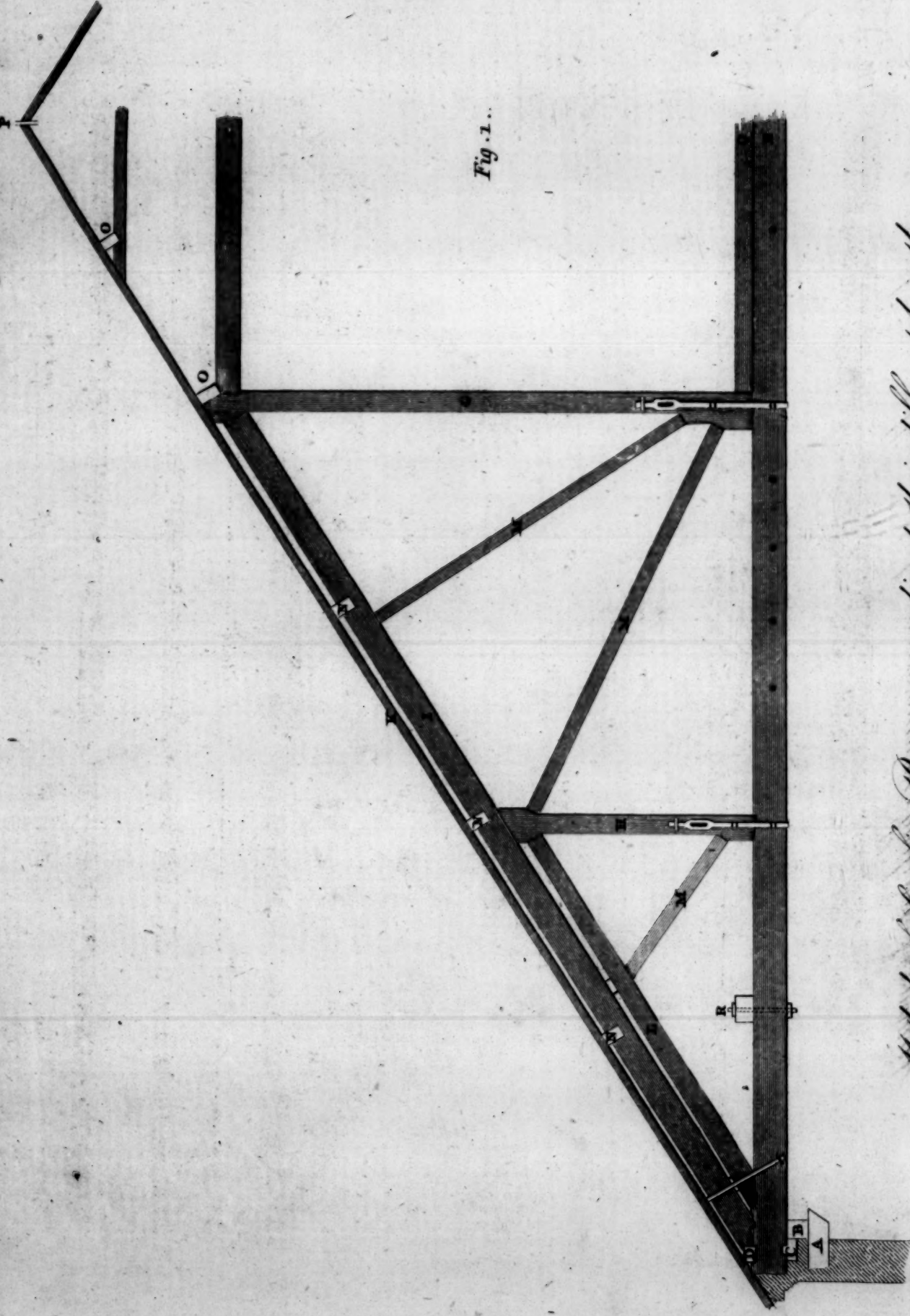


Fig. 1.

Methods of Scarping Beams, according to their different lengths.

Fig. 2.



Fig. 3.



Fig. 4.

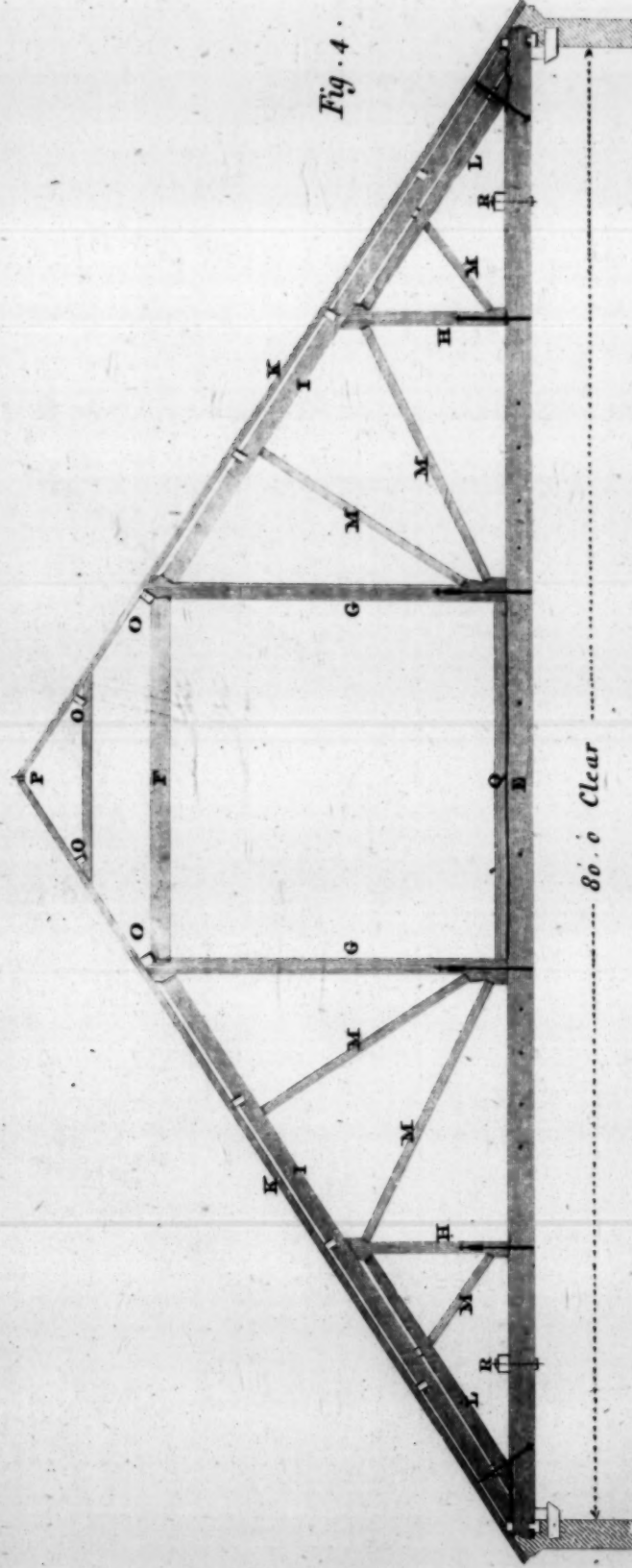


Fig. 5.



Fig. 6.



80' 0" Clear

PLATE LXXIII.

Of the Roof of Birmingham Theatre.

The span of this roof is 80 feet, the construction of the truss is well adapted to its purposes, being simple and requiring but little timber considering its magnitude. An open space of 19 feet 6 inches wide and 18 feet high, is left in the middle for the various work-rooms, &c. necessary for the services of the theatre. The thrust of the long braces, *M, M*, against the foot of the king post *G*, is effectually counteracted by the straining fill *Q*.

There is in this roof an admirable provision, which I think should never be omitted in roofs of large extent, to guard against the possibility of accident from rot or decay at the ends of the beams on the wall; the pieces marked *R*, are placed parallel with the walls at about 7 feet distance from the ends of the beams, to each of which it is secured by an iron bolt; and for a similar purpose the inner plate *B* is an addition to the usual one *C*; the wall being too thin to admit a plate proportioned in width, to the span of the roof.

The trusses are about 10 feet apart.

This roof was constructed by Mr. George Saunders, Architect, in the year 1794.

FIG. 1, shews half the truss to a larger scale.

FIG. 4, shews the truss entire.

Scantlings.

<i>A</i> , oak corbal	-	-	9 in. by 5	<i>I I</i> , principal rafters	12 and 9 in. by 9
<i>B</i> , inner plate	-	-	9 in. by 9	<i>K K</i> , common rafters	- 4 in. by 2½
<i>C</i> , wall plate	-	-	8 in. by 5½	<i>L L</i> , principal braces	9 and 6 in. by 9
<i>D</i> , pole plate	-	-	7 in. by 5	<i>M M</i> , common braces	- 6 in. by 9
<i>E</i> , beam	-	-	15 in. by 15	<i>N N</i> , purlines	- 7 in. by 5
<i>F</i> , straining beam	-	-	12 in. by 9	<i>O O</i> , upper ditto	- 6 in. by 4
<i>G G</i> , king post of oak, in the shaft	9 in. by 9			<i>P</i> , ridge piece	- 9 in. by 2
<i>H H</i> , queen post of oak, in the shaft	7 in. by 9			<i>Q</i> , straining fill	- 5½ in. by 9

FIG. 5, 6. Methods of scarfing beams.

FIG. 2, 3. The same, to a larger scale.

The example, *fig. 6*, may be continued to almost any length by breaking the joints as shewn.

PLATE

PLATE LXXIV.

The manner of framing the Tower or Spire of the Water-works at York Buildings in the Strand, London.

FIG. 1, the elevation of the whole spire, naked, consisting of fourteen stories, showing the manner of framing the timbers.

FIG. 2, the upper part to a larger size, showing the dimensions of the timbers and the manner of framing the top.

FIG. 3, plan of the top, showing how the ribs are framed into the king post, and to keep the ribs still more secure all the ends are bolted into a circular ring, whose centre is the centre of the king post.

FIG. 4, a section of the tower, showing the braces at the bottom.

FIG. 5, the manner of scarfing the angular posts.

The plan of this building is an octagon, each side at the base on the outside of the framing is 9 feet, and each side at the top is 2 feet $8\frac{1}{2}$ inches. The stories are about 7 feet 10 inches high, from the upper side of one floor to the upper side of the next.

It may be proper here to observe, it would have added much to the strength of this spire, if all the timbers had been framed together as in the upper story, see *fig. 2*.

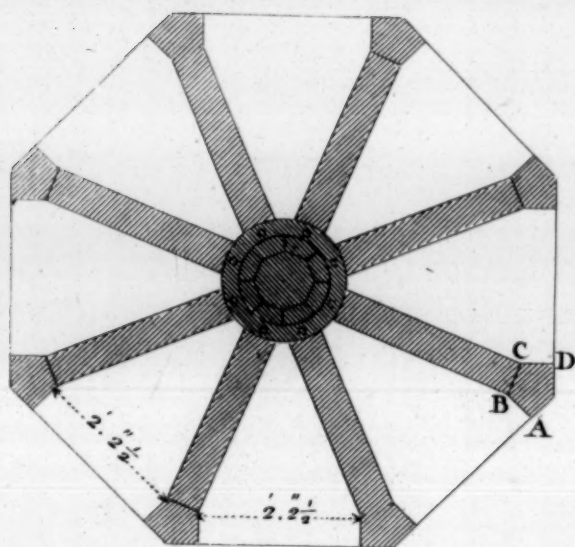
The structure was built by Mr. James King, a Gentleman of considerable eminence as a Carpenter, who was engaged in many large works, particularly in the building of Westminster Bridge.

This Tower was built, I have much reason to suppose, previous to the year 1729.

Tower of York Buildings Water Works.

Pl. 74

Fig. 3.



The sides A.B, B.C and C.D of the angular pieces are each 10 inches at bottom; and $5\frac{1}{4}$ at Top.

Fig. 5.

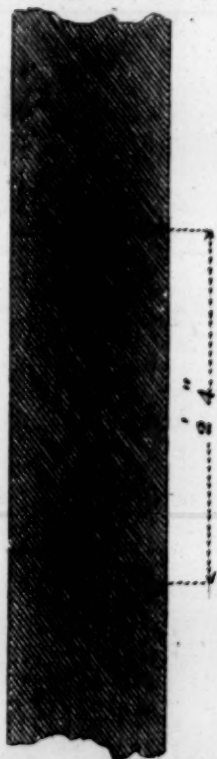
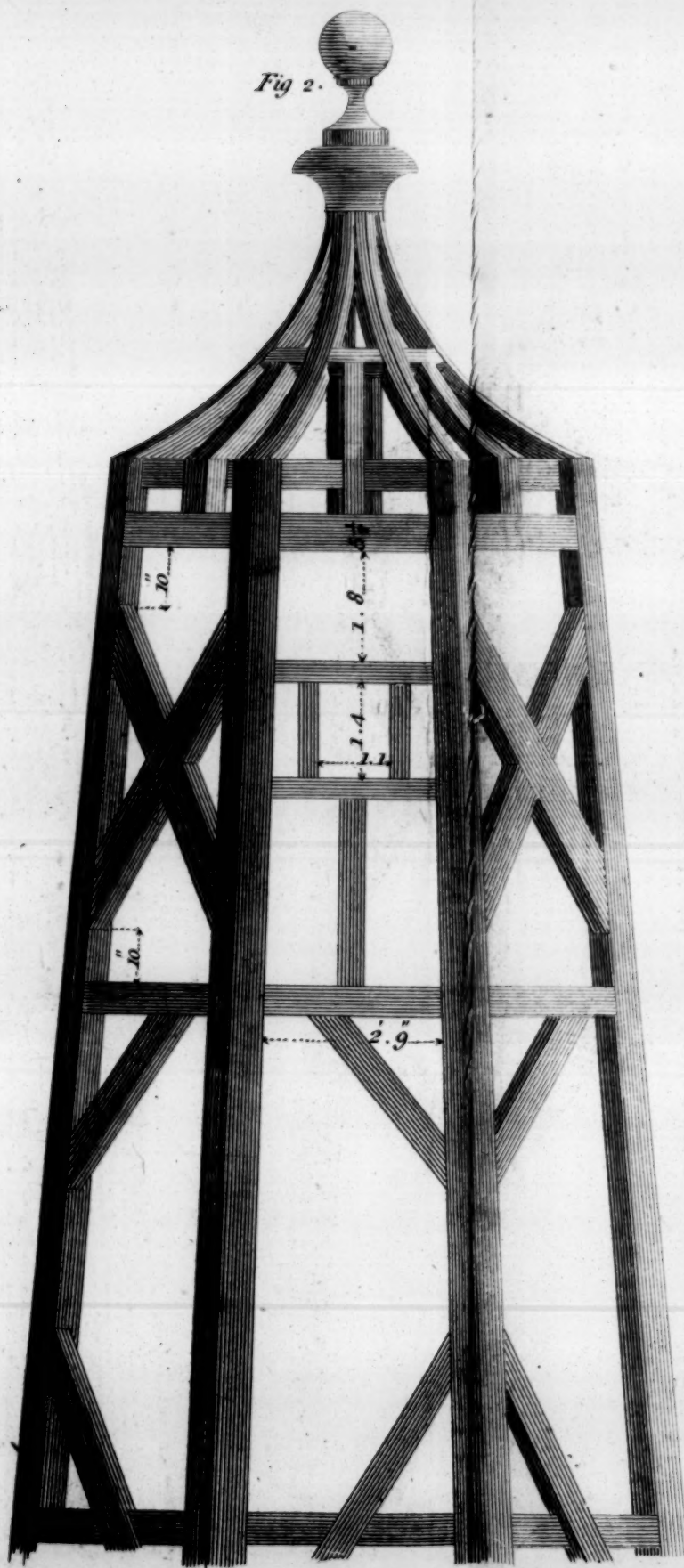


Fig 2.



The upright standards are $9\frac{1}{2}$ by 6" at bottom and 6" by $3\frac{1}{4}$ at Top.

Fig 1.

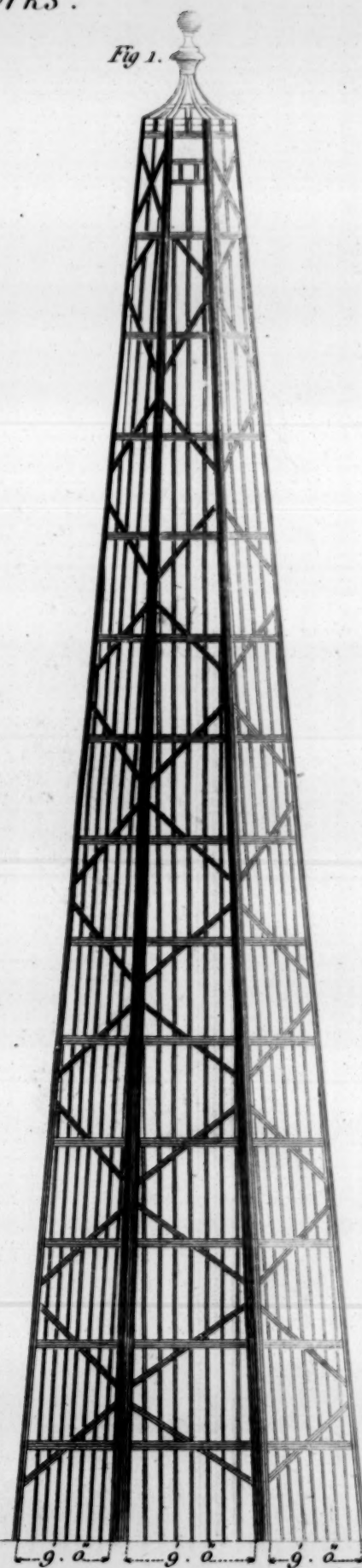


Fig 4.

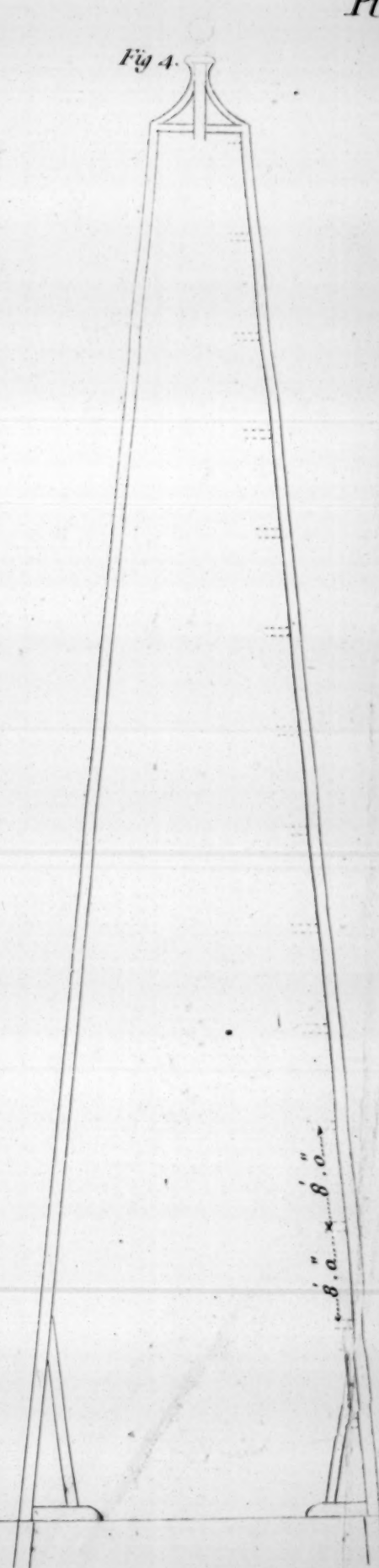






Fig. 2.

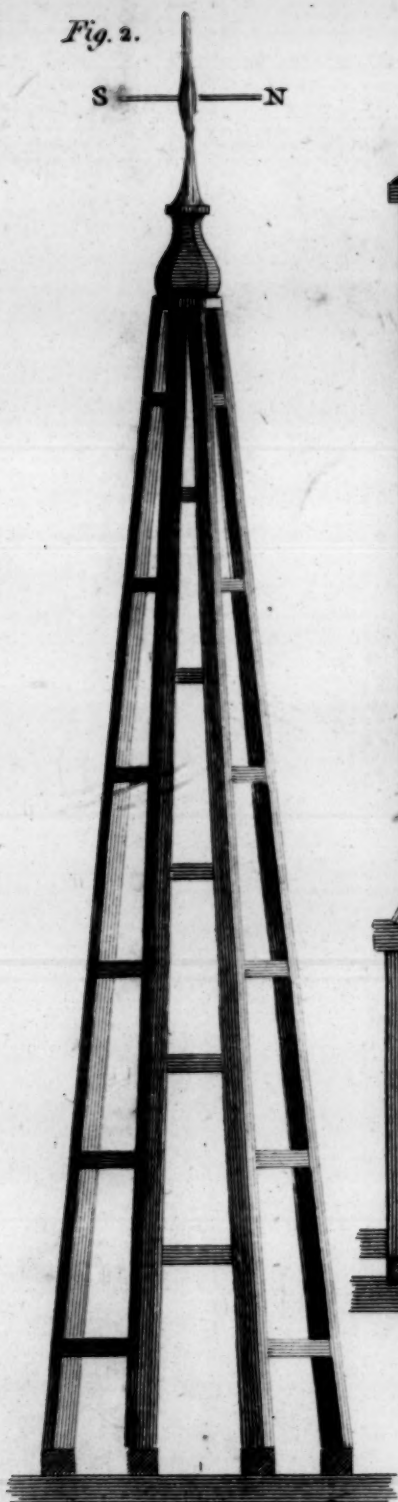


Fig. 6.

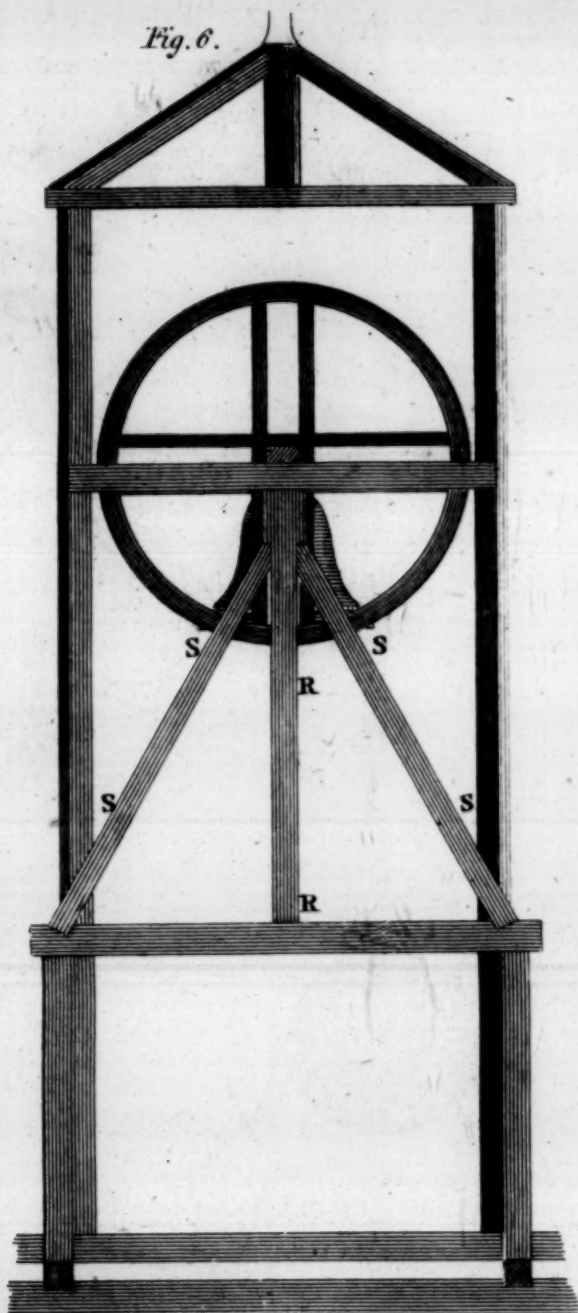
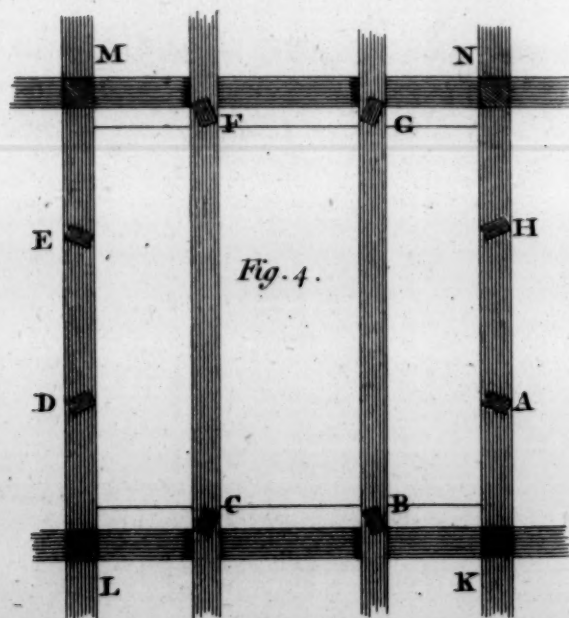
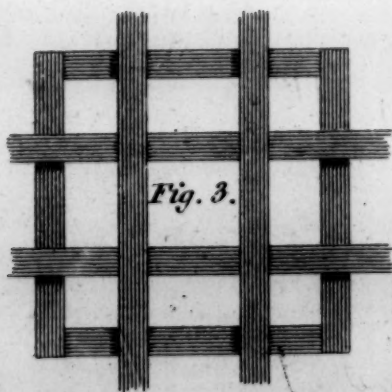
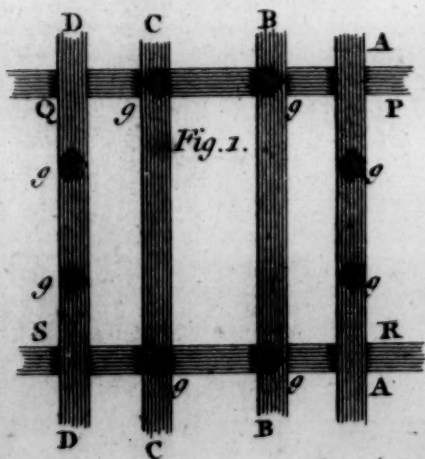
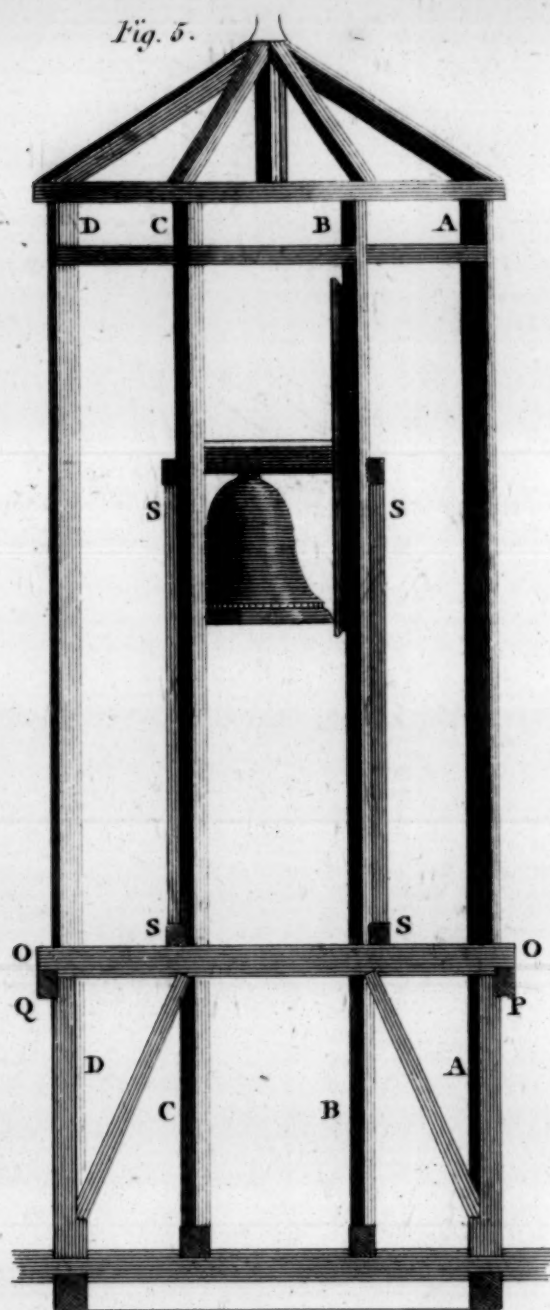


Fig. 5.



To increase the variety of Towers or Spires, I shall now give a Design for a Spire, and a Design for Turret, with the manner of hanging the Bell.

PLATE LXXV.

Design for a Spire, which may be covered with lead, showing the timbers or manner of framing it.

FIG. 1, the plan. PQ and RS , are sleepers; AA , BB , CC , DD , are beams on which the angle posts are fixed at g, g , &c. The ends of these beams should be considerably longer than shewn, which ought to be worked into the wall or timber-work of the base, so that the action of the wind may be resisted by as broad a base as possible.

FIG. 2, the elevation. The bars are equi-distant; those in the sides are in the middle of the adjoining ones, by which the mortices are at an equal distance: thus the angle posts will be kept as strong as the nature of the thing will admit. The proportion of the spire is as 5 to 3.

FIG. 3, another method of framing the floor or plan for a spire.

Design for a Turret proper for a Chapel, &c. with the truss for hanging the bell.

The base of this turret may be of stone, in the form of steps, or a pedestal, the basement is therefore framed square to a certain height; the upper part then takes a circular form; the finishing, at the upright posts, may be either pilasters or columns, supporting an entablature, with a domical or other roof.

FIG. 4, plan of basement or floor, which is square; the supports or posts being placed at K, L, M, N . The upper part being circular, the posts are placed at A, B, C, D, E, F, G, H , forming a circle of the diameter proposed.

FIG. 5, elevation of the turret; A, B, C, D , the posts which form the upper or circular part of the tower, against which the pilasters, &c. are to be fixed. P and Q are the posts which form the base or square part of the turret. OO , a stretcher, under which are the ends of others, which brace or bind the square or pedestal part of the turret. SS , and SS , the braces which support the bell.

FIG. 6, the elevation on the other side, showing the truss to support the bell; RR the post; SS , and SS braces. If this turret is finished with a cornice, frieze, and architrave, the space between the circular rings at the top may be filled in with blockings, proper to fix them to.

OF MORTICES, TENONS, IRON STRAPS, &c.

The foregoing plates of Roofs having exhibited a variety of the best examples, in form, construction, and magnitude, and suited to most occasions of importance; to complete the subject, I shall, in the three following plates, give examples of, and demonstrate the best construction of *Mortices* and *Tenons*, and the best position for placing *Iron Straps* on the ends of beams, to secure them in their places; matters of the greatest importance to the *Practical Carpenter*, and without a due knowledge of which, the best construction may be spoiled in the execution.

PLATE LXXVI.

Of Tenons and Mortices, according to their position.

Observe. If a piece of framing is to stand perpendicular, such as partitions, &c. and if there be no pressure on either side, or an equal pressure be on each side of the framing, then it will be best to have the mortice and tenon in the middle of the wood, as *AB*. Further

Observe, in framing for floors, &c. where the pressure is entirely on one side, the mortices and tenons ought to be nearest to that side on which the pressure is, because if a piece is cut out on that side on which the pressure is, the timber or beam will be but little weakened, if a piece of hard wood is drove tight into the cavity or notch: in flooring, where the weight of the materials and every additional weight tend to press downward, the whole stress or strain will be upon the upper side of the timbers, wherefore the mortice and tenon ought to be as shewn at *C, D, E, F*; that at *C, D*, is the most simple method. *E, F*, is another method by which to obtain more strength in the tenon by an additional shoulder or bearing below, which is further aided by the inclined butment or bearing above.

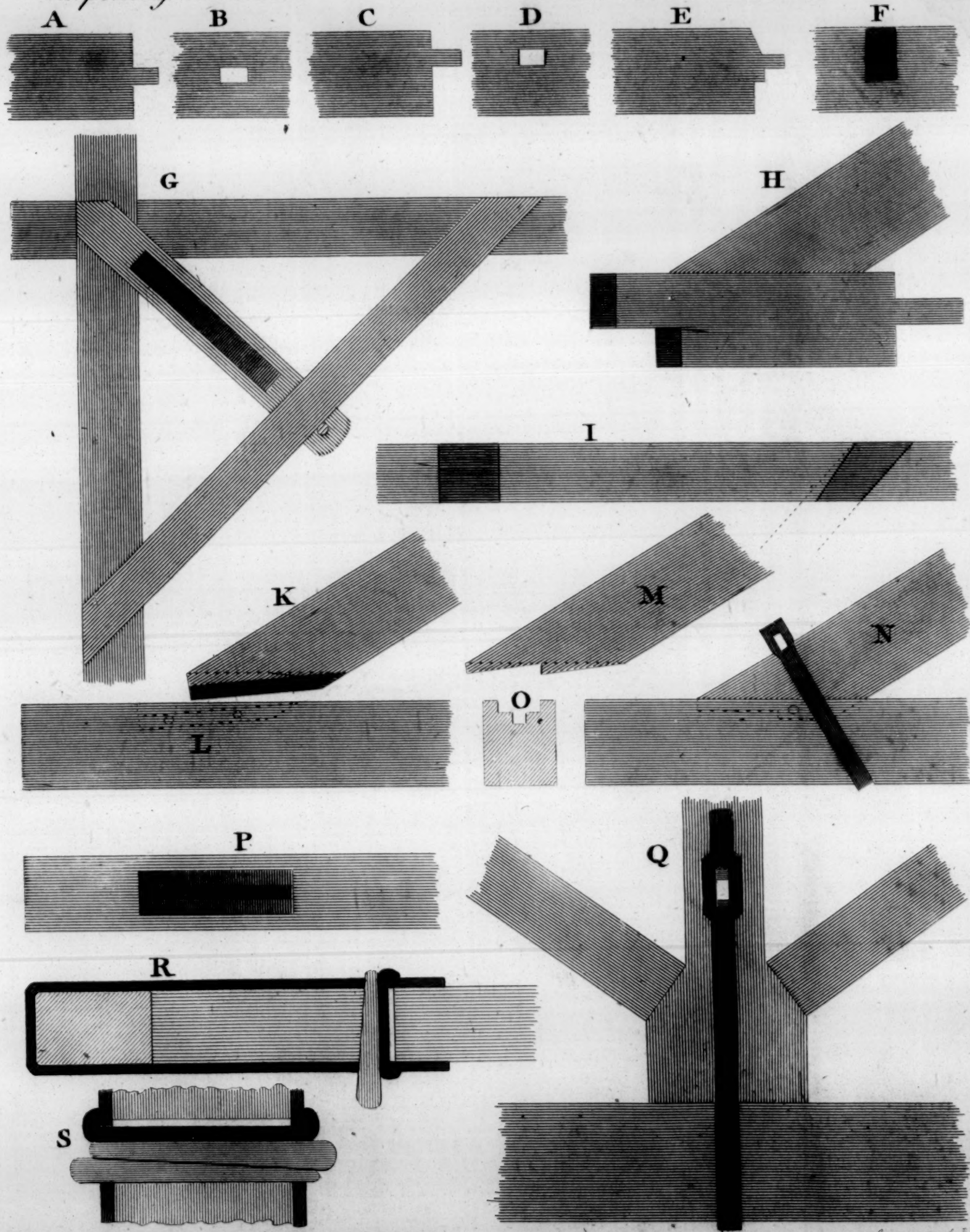
G, the manner of framing together an angular wall-plate for a hip-rafter, with the dragon beam to support the rafter.

H, the hip rafter, fixed into the dragon-beam, shewing its tenon, and the manner in which it is cut, to be fixed on the wall-plate.

I, one of the wall-plates, shewing the halving to receive the other plate, and the cutting, for dove-tailing the angular brace.

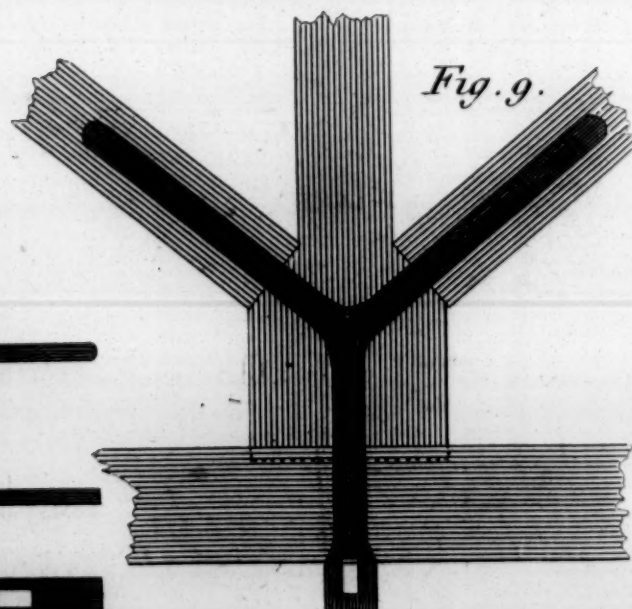
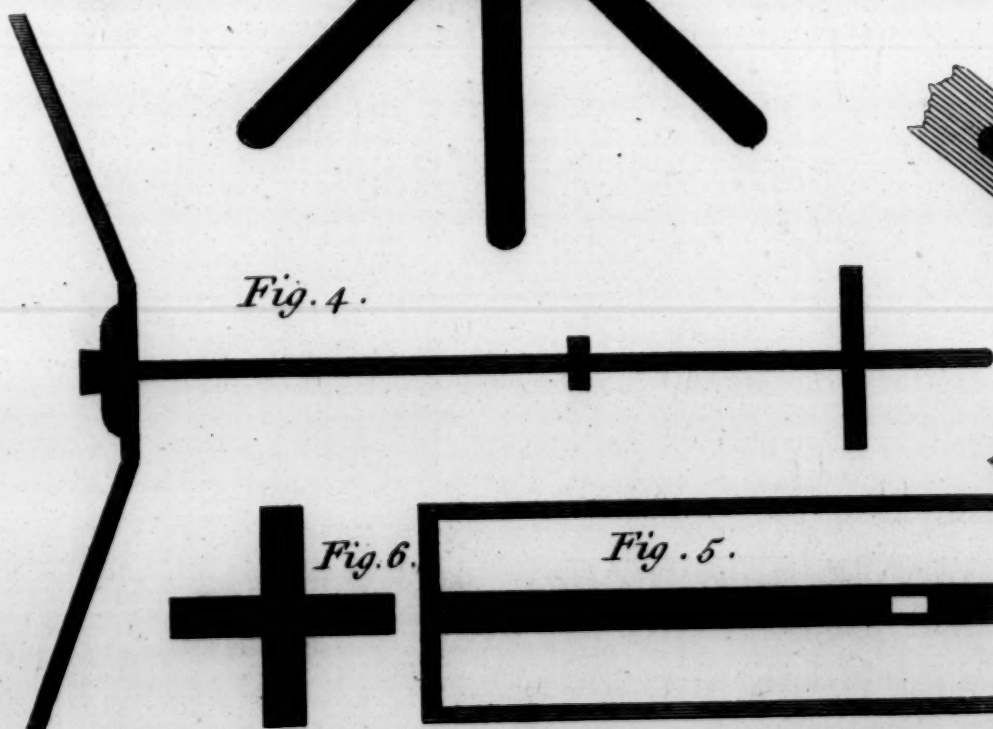
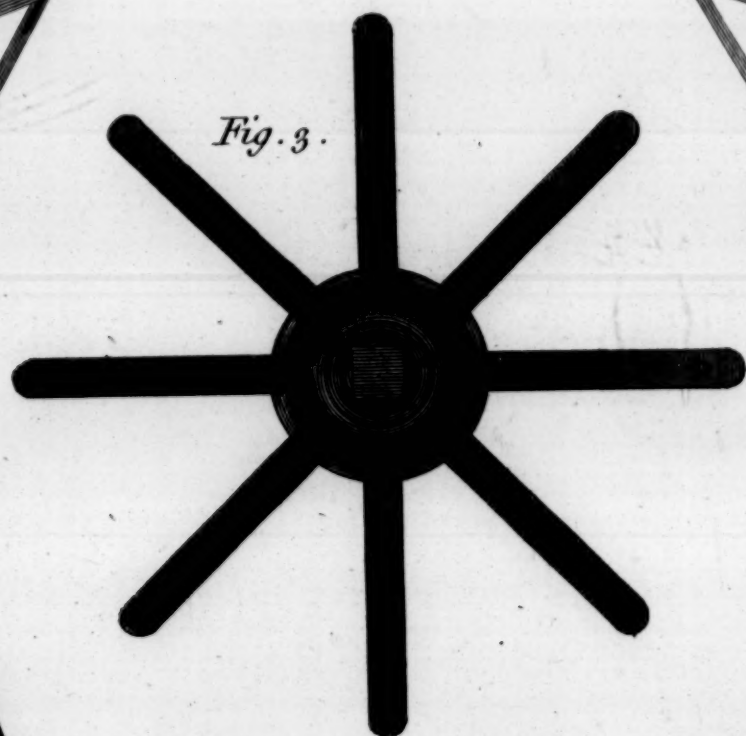
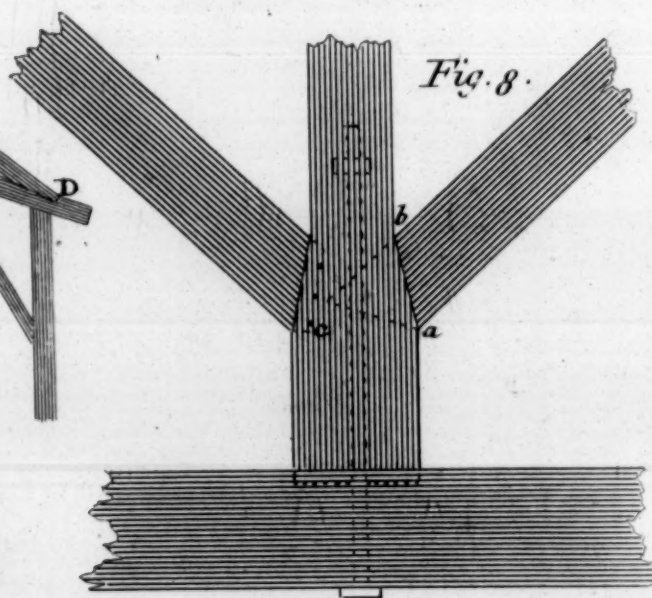
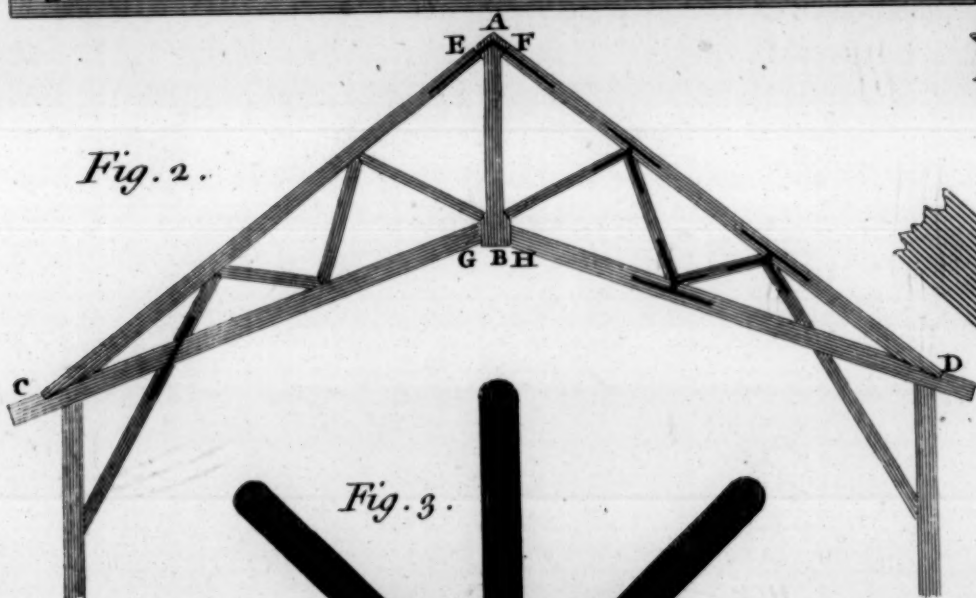
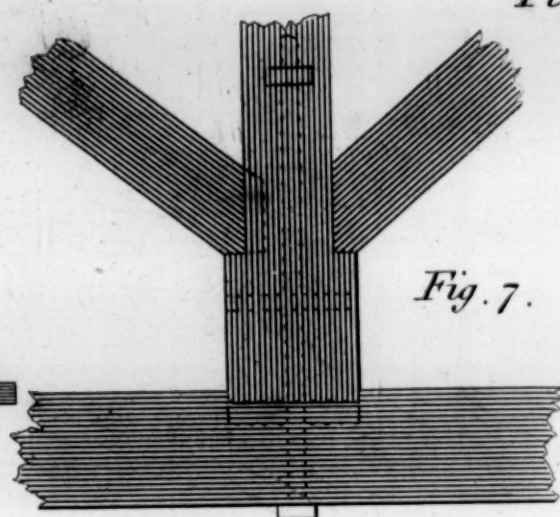
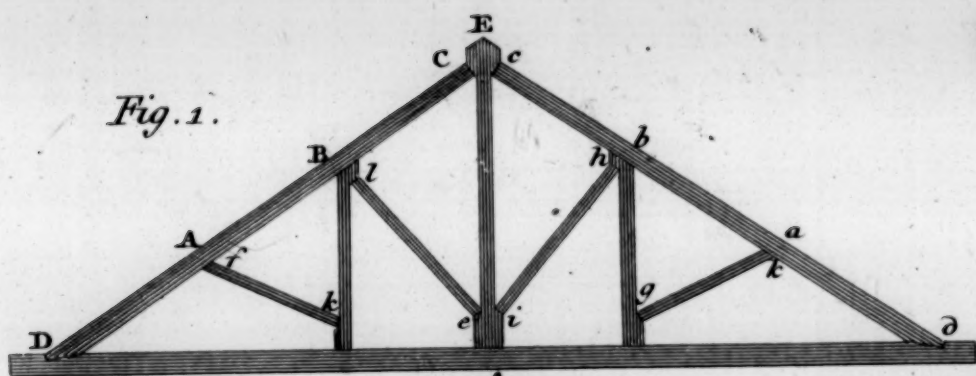
K, L, the manner of tenoning hip or principal rafters.

M, another method much in use for cutting the feet of the principal rafters, in order to give them a double resistance on the tie-beam; but as the beam in this case is necessarily cut across the grain, in order to receive the rafter, that part of the tie-beam, which is









left standing, to receive the heel of the rafter, is easily split away; a more effectual method, therefore, of obtaining a double resistance is shown at *N*, where the socket is cut parallel to the grain of the wood.

O, section of the tie-beam across the socket, shewing the mortice of *N*.

P, the upper side of the tie-beam, shewing the socket and mortice of the section *O*.

Q, the manner of strapping a king-post to a tie-beam, shewing the braces and joggles. The best form of a butment for a brace, which is joggled into a king-post, is to have the end of the brace which forces against the joggle, perpendicular to the sides of the brace; by this means it will have no tendency to slide to one side or the other, but will keep firmly on its butment.

R, a section of the king-post and tie-beam, shewing the manner of wedging and tightening the strap, with a single wedge, in order to draw the tie-beam close to the king-post.

S, a section of the same part, to a larger scale, with a double wedge, which will act much easier than a single wedge in driving, as it will have less action upon and resistance from the ends or cross grain of the wood.

PLATE LXXVII.

OF IRON STRAPS, &c.

In order to establish a rule for the best method of fixing IRON STRAPS, it is necessary to enquire in what manner a truss is affected by the different pressure of the purlines which support the small rafters and the covering, which also will demonstrate the true use and service of the KING-POST.

FIG. 1. Let the two rafters *CD*, and *cd*, be firmly fixed to the tie-beam *Dd*, and the upper ends *Cc*, be fixed to the king-post *E*, the joggles being at right angles with the rafters.—It is evident if a weight acts upon the point *E*, the vertex of the truss, it will not descend; for suppose the rafters to revolve at the points *D, d*, to descend, the points *C, c*, must come nearer to each other; but this cannot be so long as the top of the king-post is incompressible, and therefore neither the king-post nor the rafters can descend. Instead of a weight acting at *E*, suppose a weight hung or suspended there, acting in the direction of the king-post *Ee*; a weight thus suspended will endeavour to make the king-post descend, the same as when acting at *E*, now in the endeavour of the king-post to descend, it must force upon the rafters *CD* and *cd*; but as these are fast at their butments or points *D, d*, the force which acts at the points *C, c*, will push the rafters in the direction of *CD* and *cd*, consequently the force of the thrust will terminate on the

K

tie-

tie beam, at the points *D*, *d*, and will endeavour to extend the beam. Wherefore if this truss should fail, the rafters must burst, and the tie-beam be broken by tension.

Now if this roof has purlines which stand upon the points *A*, *B*, *a*, *b*, a force acting on these points will easily bend the rafters, wherefore it will be necessary to find some fixed points in order to keep the points *A*, *B*, *a*, *b*, from descending, or, in other words, to prevent the rafters bending. To this purpose fix the side-posts *l k* and *h g*, under the purlines *B*, *b*, and also put in the braces *l e*, and *h i*, so that the butments at *l*, *e*, *i*, *h*, may be at right angles to the direction of the braces; then the points *B*, *b*, cannot descend, for they are supported by the points *e*, *i*, on the king-post, which was shown to be immovable, and therefore the points *B* and *b*, will also be immovable: further, the shoulders at *l* and *h*, will prevent the side-post *l k* and *h g*, descending, and consequently if the braces *f k*, and *g k*, are placed under the points *A* and *a*, and are firmly fixed to the bottom of the posts *l k*, and *h g*, the points *A* and *a* will also be supported.

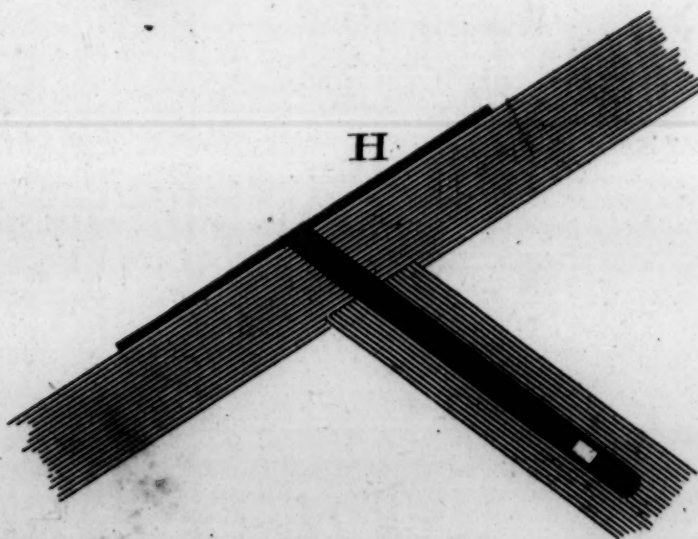
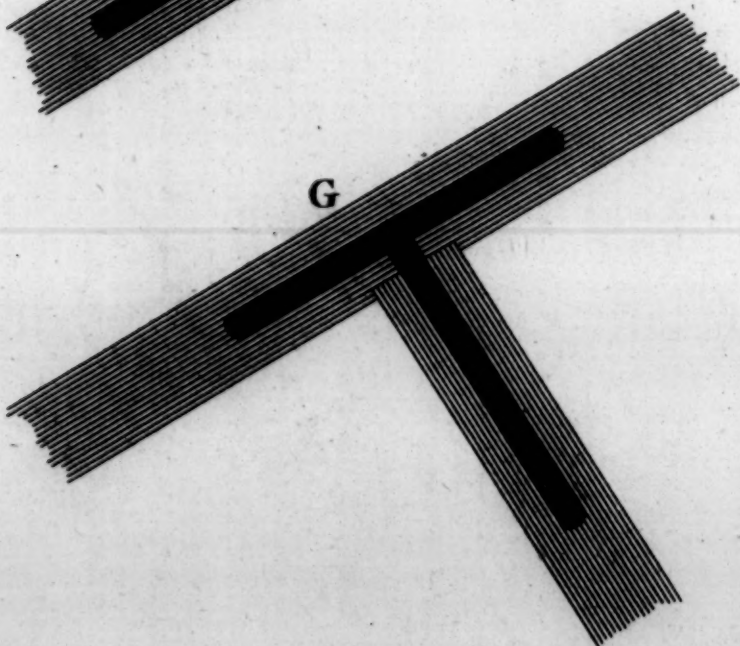
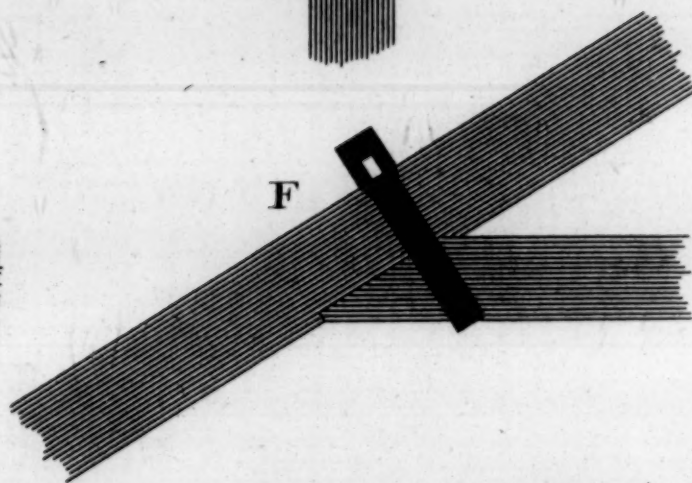
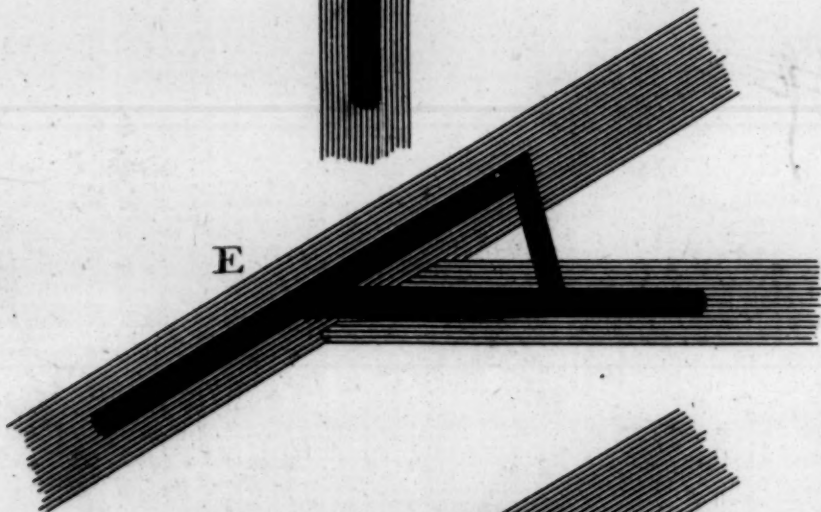
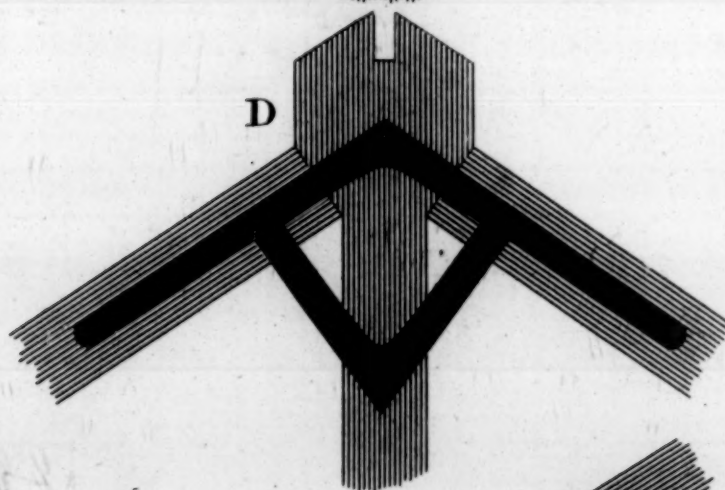
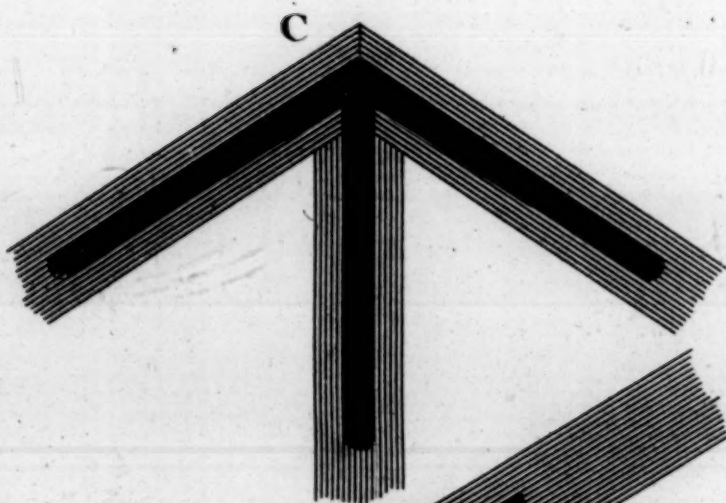
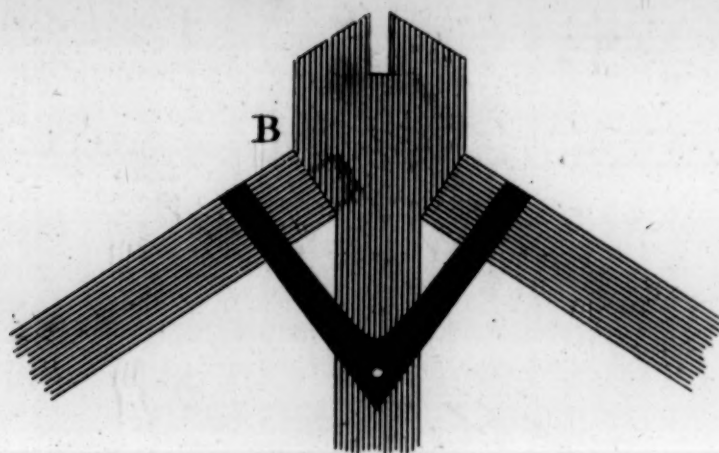
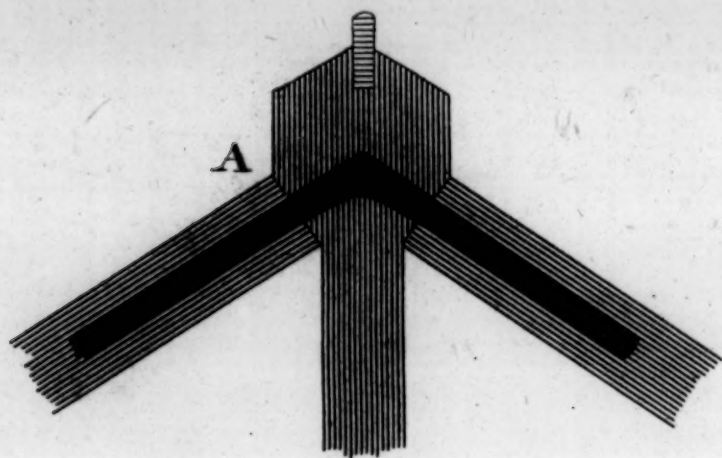
As wood is more apt to shrink sideways than in length, so the king-posts and side-posts, in consequence of the perpendicular position of the grain of the wood, and also in proportion to the quality of the wood, will be liable to shrink, the rafters of consequence will descend; this must be guarded against by the application of iron straps in proper positions, as will be afterwards shown.

To obviate all the objections of the shrinking of the king-post, we have instances of their being made of iron, as in the roof to Greenwich Hospital, Plate 71; and this might be used with propriety in the circumstances of the rafters butting against each other, as in *fig. C*, Pl. 78. See also this further applied in *fig. 1*, Pl. 79.

On the shrinking of the king-post, it should be observed, that in a roof of 50 feet span, where the rafters are 30 feet long, a shrinking of half an inch at the king-post will occasion the whole of the roof to descend nearly one inch; and if the pitch is less than a third, the effect will be increased.

FIG. 2. Section of a truss for a *circular building*. *AB*, the king-post, which must have as many sides as there are trusses in the roof, *GC* and *HD* are tie-beams, affixed to the king-post, *EC* and *FD*, are the principal rafters: now it is evident from the mere weight of the materials, that the timbers of this roof will descend or fall down, if some method is not taken to prevent it;—for suppose the joints *C*, *D*, *E*, *F*, *G*, *H*, to be loose, then the heads of the rafters will press against the king-post at *A*, and the bottom of the rafters forcing against the tie-beams at *C*, *D*, will separate them from the bottom of the king-post *B*; but if the tie-beams are firmly fixed to the king-post, then this roof will be secure. Now the method I propose for effecting this, is, to tie all the beams to the king-post as a common centre by means of an iron strap, in the form of *fig. 3*, consisting of as many branches as there are tie-beams to be united; this figure also shows the plan of the roof. Now the centre of this strap being made secure to the king-post, and an arm being bolted to each of the tie-beams, will I think render the whole secure and permanent. *Fig. 4*, is a section of the strap, shewing the bolts and cross nuts which are to be let into the king-post, to fasten the plate up to the bottom of the king-post. *Fig. 5*, is





is another method of fastening the plate to the king-post, by straps or braces, crossing the centre of the strap at right angles, and which is to be tightened by wedges. *Fig. 6*, is a plan of the same.

FIG. 7. The manner of joggeling a pair of braces into the bottom of a king-post, when its thickness will not admit of square joggles. This figure also shews the method of uniting or suspending the tie-beam to the king-post, by an iron bolt and nuts, as expressed by the dotted lines.

FIG. 8. Is another method of joggeling the braces with bevel joints, when the bottom of the king-post is narrow; but by this method the braces are liable to slide away from the joggle, if there be not a tenon sufficiently strong to prevent it. Some carpenters make the tenon in the form of an isosceles triangle, as abc , of which the side ac , is equal to ab ; but this method cuts and weakens the king-post too much: the best kind of tenon under these circumstances, is as shown on the other side by the dotted lines.

FIG. 9. A method of strapping a pair of braces to a king-post, and suspending the tie-beam: that part of the king-post on which the braces rest being liable to shrink, the braces of consequence must follow, by which the principal rafters losing their support, will bend; now if a strap is fixed, as shewn by this figure, the braces will be kept secure in their position, and the rafters of consequence will not bend.

PLATE LXXVIII.

OF IRON STRAPS.

FIG. A. The upper part of a king-post and principal rafters, strapped together. The strap is here fixed in the direction of the rafters, and if well bolted to the rafters it will prevent them coming nearer together at the top in case the king-post does shrink; consequently the rafters will not fall in: wherefore the roof will always be maintained in the exact position as first executed.

FIG. B. Straps are frequently fixed in this manner: that is, perpendicular to the edge of the rafter; but this will not prevent the upper ends of the rafters coming nearer to each other, for the braces which are supposed to act against the bottom of the king-post, or the swag of the tie-beam, will force down the king-post, and the form of this strap will not prevent the ends of the rafters closing to the head of the king-post, in case it has shrunk: but if a purline, or any particular weight be over the strap, then the position for resisting that weight will be good; but in the construction of a roof purlines are seldom or never placed at the head of a rafter: the only force which acts in the direction

of this strap, is the weight of this portion of the rafter, which is inconsiderable when compared with the quantity of force which acts in the direction of the rafters.

FIG. C. Another method of strapping the principal rafters to a king-post. When the ends of the rafters meet, as in the construction shown by this figure, the roof will be but little liable to swag or fall in, in the middle; as there is no substance between the rafters, there can be no shrinking.

FIG. D. Shows the method of strapping the principals to a king-post, in circumstances where the rafters are liable to two pressures, viz. one, in the direction of their length, and the other perpendicular to that direction.

FIG. E. The manner of strapping a collar-beam to a principal rafter. If a roof has a collar-beam and a king-post; and, if the strap which unites the principals to the king-post be placed in the middle of the principal rafter, as *fig. A*, so ought the strap which fixes the collar-beam to the rafter to be placed in the middle of the principal rafter.

FIG. F. Is in another method for the same purpose: but supposing the feet of the rafters to be extended by the weight of the roof, which will endeavour to extend the collar-beam, then this strap will turn round upon the back of the rafter, and consequently the rafter will be separated from the collar-beam;—now the construction of the strap, *fig. E*, is perfectly secure from such a strain.

FIG. G. A strap proper for fixing a brace to a principal rafter. When the strap which unites the king-post to the principal rafters is fixed in the middle of the rafters, as at *A*, then this is the best position, because when all the straps are fixed alike, they keep the edges of the rafters in straight lines.

FIG. H. The method of strapping a brace to a principal rafter: when the strap which unites the king-post to the rafters goes over the upper edges of the rafters, as is shown in *fig. 3*, Pl. 79.

PLATE LXXIX.

OF IRON KING-POSTS.

FIG. 1. Is a design for a truss with king-posts and queen-posts of iron, with straps going over the rafters; the feet of these posts are made in form of a saddle, and therefore the braces will have a firm butment against the iron, and will not be subject to be loose or slack by the shrinking of the tie-beam. The tie-beam is hung up by bolts through the bottoms of the saddles at *B A* and *C*: *B C* is a straining-piece, the ends of which lie in the saddles *B C*, and butt against the braces *D E* and *F G*, thereby keeping the butments at *D* and *F* secure.

FIG. 2.

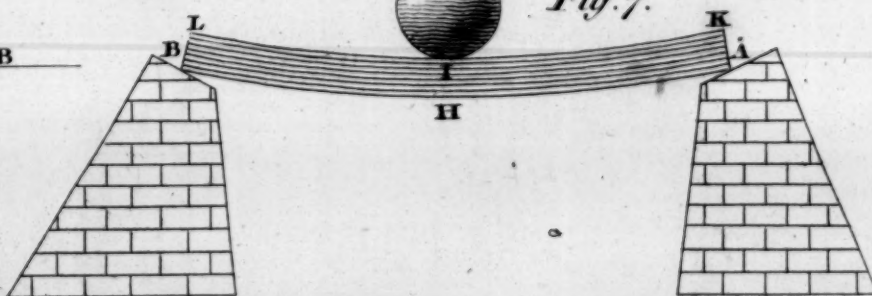
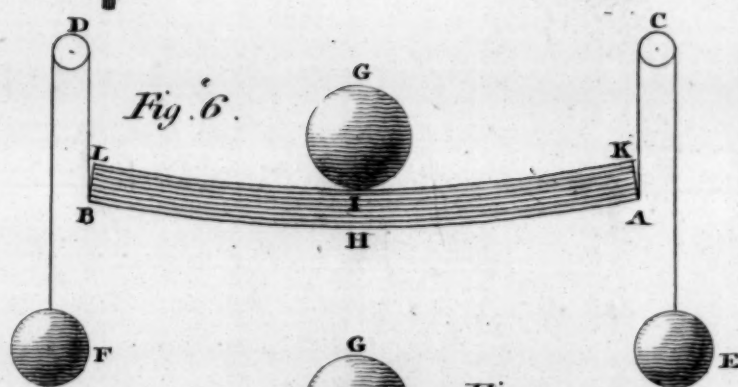
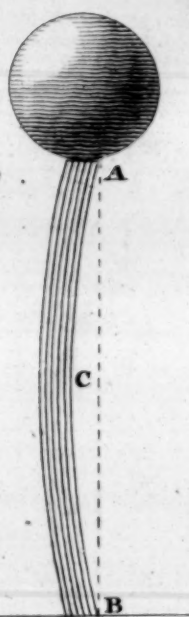
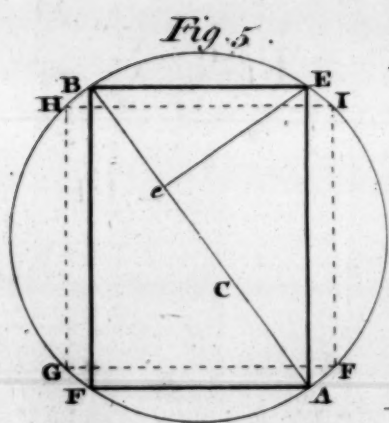
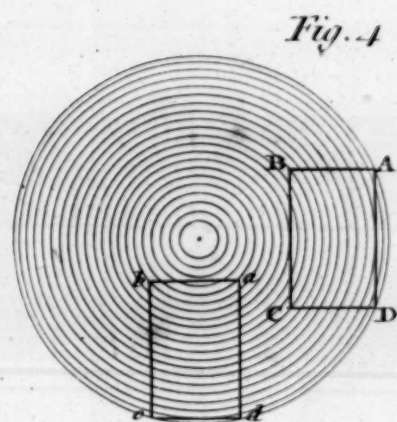
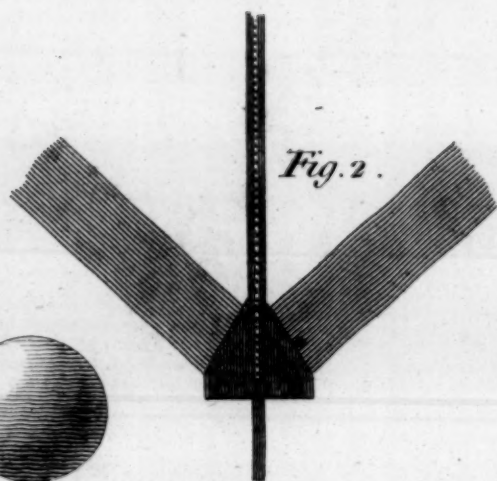
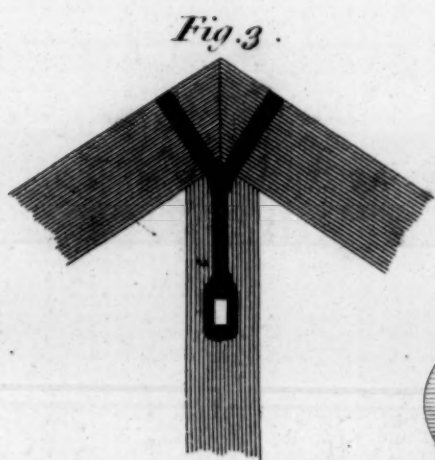
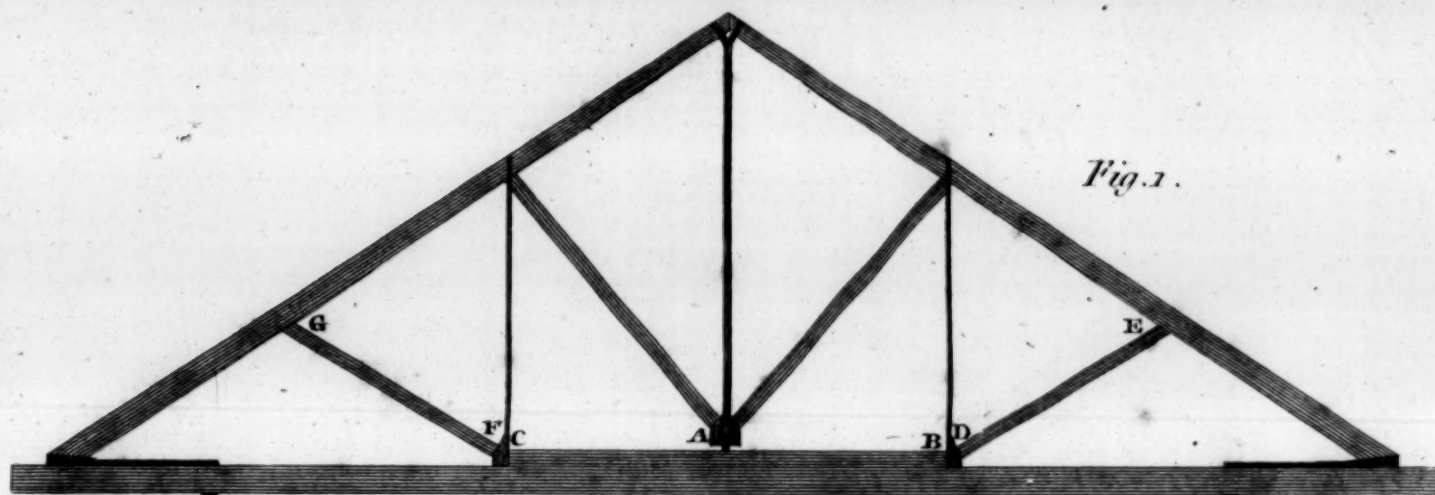




FIG. 2. The saddle at *A*, to a larger scale, shewing the butment of the braces by dotted lines, either with a triangular butment, as *ABC*, so that it may have a square butment, or the braces may meet each other in the line *AD*.

FIG. 3. Shews another method in addition to those already described, by which to hang up a king-post to the rafters, the ends of the rafters being in contact: The upper end of the strap is made in two branches going over the rafters at right angles to each other. The bottom of the strap is made wider, that it may be bolted in two places in the breadth, by this means to have a greater resistance.

ON THE STRENGTH OF TIMBER.

IN my former publication, I have given some investigations and rules for calculating the proportional strength of timber, founded upon the theory of the celebrated Galileo, which differs but little from the truth as will be hereafter shown: the theory supposes the timber to have no degree of elasticity, and the texture perfectly uniform, in which case it will be neither compressed nor extended, and when it breaks, all the particles will be separated at once. The rule upon this supposition for finding the relation of the strength of different pieces of the same texture, will be accurately the proportion of the numbers arising by multiplying the square of the depth of each piece by its breadth, and divided by its length: consequently the harder, non elastic or more brittle, a piece of timber is, the nearer will it correspond to this rule. Wherefore it appears that the rule which will apply for finding the relative strengths of one species of timber, will not suit for other kinds whose textures are of a different nature.

From the preceding considerations, therefore, it appears we must not hope to find a rule which shall apply to scantlings of all timbers generally; and the only means on which we must place any hope of discovering a rule for ascertaining the relative strengths of different kinds of timber, is from the result of a great number of experiments made on each species with all possible care and accuracy, and upon a large scale. But the labour and expence attending such experiments on a scale likely to be at all useful, far exceed the abilities of individuals who might otherwise be disposed to investigate this useful branch of mechanical knowledge. This grand objection no doubt has been the cause why so little has been done to determine this subject by experiments: yet as we are not absolutely without some lights, we shall proceed to lay the same before our readers in as concise a manner as the clearly explaining the matter will admit.

The first authority to our purpose is what *Belidor* has given on this subject in his *Science des Ingenieurs*.

BELI-

BELIDOR'S EXPERIMENTS.

The column *B*, contains the breadths of the pieces in inches; the column *D*, contains their depths; the column *L* contains their lengths; *P* the weight (in pounds) which broke them, when hung on their middles.

In order to obtain the best idea of the strengths of pieces of different dimensions, with more certainty, three pieces of each dimension were tried, a medium among them being more accurate than a single experiment.

The column *M* contains the mediums.

The experiments were made on oak, of equal quality, and tolerably well seasoned.

	B	D	L	P	M
Experiments 1st, ends loose	1	1	18	400 415 405	406
Experiments 2d, ends firmly fixed	1	1	18	600 600 624	608
Experiments 3d, ends loose	2	1	18	810 795 812	805
Experiments 4th, ends loose	1	2	18	1570 1580 1590	1580
Experiments 5th, ends loose	1	1	36	185 195 180	187
Experiments 6th, ends fixed	1	1	36	285 280 285	283
Experiments 7th, ends loose	2	2	36	1550 1620 1585	1585
Experiments 8th, ends loose.	$1\frac{2}{3}$	$2\frac{1}{3}$	36	1665 1675 1640	1660

By comparing experiment the 1st, with experiment 3d, the strength appears proportional to the breadth, the length and depth of each piece being the same.

By comparing experiments the 1st and 4th together, the strength appears as the square of the depth nearly, the breadth and length being all the same.

By comparing experiment the 1st and 5th together, shows the strength to be nearly as the lengths, inversely, the breadth and depth of each piece being the same.

By comparing experiments 5th and 7th together, shows the strengths, nearly in proportion to the breadth, multiplied by the square of the depth, the length being the same in both.

By comparing experiments 1st and 7th together, shows the strengths to be as the square of the depth, multiplied by the breadth, and divided by the length. Experiments 1st and 2d, show the increase of the strength by fastening the ends, to be, in the proportion of 2 to 3. Experiments the 5th and 6th, show the same thing.

By

By the above experiments it appears that the rule founded upon the Galileon hypothesis for finding the comparative strength of timber, is nearly true. But as it would be wrong to draw conclusions from timbers of so small scantling, as in the above experiments, we shall, after making the following observation, give an abstract of the experiments of *M. Buffon* and those of *M. du Hamel*, men of acknowledged abilities, who were directed by the government of France to make experiments on this subject; and who were supplied with ample funds and apparatus for the purpose, and had the choice of the best subjects in all the forests of France. The reports of *M. Buffon* may be found in the memoirs of the French Academy, for the years 1740, 1741, 1742, 1768, and those of *M. du Hamel*, in his work, *Sur l'Exploitation des Arbres, et sur la Conservation et le Transportation de Bois*.

But we observe, the chief cause of the irregularity in such experiments, is the fibrous, or rather plated texture of timber, which consists of annual additions, whose cohesion with each other is vastly weaker, than that of their own fibres. Let *fig. 4, Pl. 79*, represent the section of a tree, and *ABCD*, and *abcd*, the section of two battens, to be cut out of it, for experiment; let *AD*, and *ad*, be the depths; and *DC*, *dc*, the breadths; the batten *ABCD*, will be the strongest; for the same reason that an assemblage of planks, set edge ways, will be stronger than the same number of planks laid above each other.

M. Buffon found that the strength of *ABCD*, was to that of *abcd*, in oak, nearly as 8 is to 7.

The authors of the different experiments, we have reason to fear, were not very careful that their bars had their plates all disposed the same way.

As great beams occupy much, if not the whole, section of the tree, and from this it has happened that their strength is less than in proportion to that of a small lath or batten; for which reason a set of experiments ought to be carefully made on each, as all large buildings require a great number of both kinds: as girders and other beams for supporting large weights, so small bars or battens are employed in making joists, rafters, purlines, &c., all of which are for the purpose of carrying or discharging weights.

M. DE BUFFON'S EXPERIMENTS.

The following table exhibits a number of experiments on bars of sound oak, clear of knots, each bar being four inches square.

The column No. 1, contains the length of the bar, in feet, between the two props.

The column, No. 2, contains the weight of the bar, the second day after it was felled, in pounds.

The column, No. 3, contains the number of pounds necessary for breaking the bar in a few minutes.

The column, No. 4, contains the number of inches it bent down before breaking.

The column, No. 5, contains the number of minutes that each respective piece was in breaking.

In this table two bars were tried of each length, each of the first three pairs consisted of two cuts of the same tree; the one found next to the root, was always found to be the heaviest, stiffest and strongest; from which M. Buffon recommends a certain and sure rule for estimating the goodness of timber by its weight; he finds that this is always the case when the timber has grown vigorously, forming thick annual layers. But he also observes that this is only during the advances of the tree to maturity, for the strength of the different circles approach gradually to an equality during the healthy growth of the tree.

1	2	3	4	5
7	60 56	5350 5275	3.5 4.5	29 22
8	68 63	4600 4500	3.75 4.7	15 13
9	77 71	4100 3950	4.85 5.5	14 12
10	84 82	3625 3600	5.83 6.5	15 15
12	100 98	3050 2925	7 8	

Experiments on other sizes were made in the same manner: a pair, at least, of each length and scantling was taken; the mean results is contained in the following table. The beams were all square, and their sizes in inches are placed at the head of the columns, and their length, in feet, in the first column. The column A exhibits the strength which each of the five inch bars ought to have by the theory.

M. Buffon, found by numerous experiments, that oak timber lost much of its strength by drying or seasoning, and therefore in order to secure uniformity, his trees were all felled in the same season of the year, were squared the day after, and tried on the third day. Trying them in this green state, gave him an opportunity of observing a very curious phenomenon.

When the weights were laid briskly on, nearly sufficient to break the log, a smoke was observed to issue from each end, accompanied with a hissing noise, which continued while the tree was bending and cracking; owing to the strain which must arise by the bending of the log, in which state it must be both compressed and extended.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14		5300	7475	13225	19775	5763
16		4350	6362	11000	16375	5042
18		3700	5562	9245	13200	4482
20		3225	4950	8375	11487	4034
22		2975				3667
24		2162				3362
28		1775				2881

From

From the above experiments some conclusions respecting the law of the strength of oak timber may be deduced, from which it will be seen whether the theory already established is sufficiently accurate, or if not, they will show in what manner it ought to be corrected.

M. Buffon considers the experiments upon the five-inch bars, as the standard of comparison, having both extended these to a greater length, and having tried more pieces of each length.

The theory determines the relative strengths of bars of the same section, to be inversely as their lengths; but if the five experiments in the first column, be excepted, there will be found a very great deviation from this rule: thus the five-inch bar of 28 feet long, should have half the strength of that of 14 feet or 2650; whereas it is but 1775; the bar of 14 feet should have half the strength of the seven feet, or 5762, whereas it is but 5300; and in like manner the fourth of 11,525 is 2881; but the real strength of the 28-inch bar, is but 1775. The column *A*, exhibits the strength that each of the five-inch bars ought to have, by the theory, which decreases much slower than those shown by the experiment; and therefore it appears, that the strength of different pieces of timber decrease much quicker than that of the inverse ratio of their lengths; but in what ratio precisely, the strength decreases, would be almost impossible to know, as there is not a sufficient number of experiments for the purpose; the few that have been tried are so very anomalous, as will appear by taking the differences between those in the third column, found by the experiments, from their respective numbers under *A*, in the seventh column, as found by the rule, which are respectively, 298, 656, 943, 648, 463, 692, 782, 809, 692, 1200, 1106; by comparing these numbers together, it is easy to see the impossibility of discovering any progression, or regular increase; for example, the third difference is greater than any of the preceding, and less than any of the proceeding, excepting the two last, and therefore it appears, that no rule can be founded on these experiments, for finding the relative strength of timber, but what will in many cases differ very considerably from that which ought to correspond to it; in the table however, the rule given in my former calculations may, if somewhat corrected, correspond nearly with the five-inch bars, as follows: from the length of the required piece, take the seven feet length, and multiply the difference by the number 1474, and divide that product by the length, and subtract the quotient from the number of pounds found by the former rule, and the remainder will be the answer.

M. Buffon uniformly found that $\frac{2}{3}$ ds of the weight which was sufficient to break a beam at first, sensibly impaired its strength, and frequently broke it, at the end of two or three months, and one half of this weight brought it to a certain curvature, which did not increase after the first minute or two, and may be borne by the beam for any length of time.

One-third seemed to have no permanent effect on the beam; but it recovered its rectilinear shape completely, even after it had been loaded several months, provided that the timber was seasoned when first loaded; that is to say, one-third of the weight which would quickly break a seasoned beam, or one-fourth of what would break one just felled, may lie on it for ever, without giving the beam a set.

The agreement of the numbers, found by the rule of the breadth, being multiplied by the square of the depth, appears to deviate less from the experiments of Buffon, than that

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of the inverse ratio of the length ; but even this rule applied to softer woods, will differ greatly from the truth, which must be evident when we consider a beam just breaking, that it will be strongly compressed on the side nearest to the axis of fracture, and the opposite side will be greatly extended, consequently there must be some point between the fulcrum and the opposite side, which will neither be extended nor compressed, and all the fibres lying between this point and the fulcrum, being in a state of compression, and therefore have little resistance in preventing the fracture, those fibres on the other side only are exerted.

This is fully verified by some curious

EXPERIMENTS MADE BY M. DU HAMEL.

He took 16 bars of willow, two feet long and half an inch square, and supported them by props under the ends, he broke them with weights hung on their middle. He broke four of them by weights of 40, 41, 47 and 52 pounds, the mean is 45.

He then cut four of them $\frac{1}{3}$ d through, on the upper side, and filled up the cut with a thin piece of harder wood, stuck in very tight; these were broken 48, 54, 50 and 52, the mean of which is 51.

He cut other four half through; they were broken by 47, 49, 50 and 46, the mean of which is 48.

The remaining four were cut $\frac{2}{3}$ ds, and their mean strength was 42.

Another set of experiments still more remarkable.

Six battens of willow, 36 inches long, and $1\frac{1}{2}$ square, were broken by 525 pounds, at a medium.

Six bars were cut $\frac{1}{3}$ d through, and the cut filled with a wedge of hard wood, stuck in with little force; those broke with 551 pounds.

Six bars were cut $\frac{1}{2}$ through, and the cut was filled up in the same manner; they broke with 542.

Six bars were cut $\frac{3}{4}$ ths through, and loaded till nearly broken; were unloaded and the wedge taken out of the cut; a thicker wedge was put in tight, so as to make the batten straight again, by filling up the space left by the compression of the wood; this batten broke with 577 pounds.

OF THE ABSOLUTE STRENGTH OF TIMBER.

The strain which arises by pulling timber in the direction of its length, is called Tension, this strain frequently occurs in roofs, and is therefore worthy consideration.

The absolute strength of a fibre, or small thread of timber, is the force by which every part of the fibre is held together, which is equal to the force that would be required to pull it asunder, and the force which would be required to tear any number of threads asunder, is proportional to all of them; but the areas of the sections of two pieces of timber composed of fibres of the same kinds, are as the number of fibres in each; and therefore the strength of the timber, is as the area of the sections.

Hence all prismatic bodies are equally strong; that is, they will not break in one part more than another.

Bodies

Bodies which have unequal sections, will break at their smallest part, and therefore if the absolute strength which would be required to tear a square inch, of each kind of timber be known, we shall be able to determine the strength of any other quantity whatever.

The following table is taken from Muschenbroëk's experiments, he has described his method of trial minutely; the woods were all formed into slips fit for his apparatus, and part of the slip was cut away to a parallelopiped $\frac{1}{25}$ of an inch square, and therefore the 25th part of a square inch in section; the absolute strengths of a square inch were as follows:

	lb.		lb.
Locust tree, -	20,100	Pomegranate, -	9,750
Jujeb, - -	18,500	Lemon, - -	9,250
Beech Oak, -	17,300	Tamarind, -	8,750
Orange, -	15,500	Fir - - -	8,330
Alder, -	13,900	Walnut, -	8,130
Elm, - - -	13,200	Pitch Pine -	7,650
Mulberry, -	12,500	Quince, -	6,750
Willow, - -	12,500	Cypress, -	6,000
Ash, - - -	12,000	Poplar, - -	5,500
Plum, - - -	11,800	Cedar, -	4,880
Elder, -	10,000		

M. Muschenbroëk, has given a very minute detail of the experiments on the ash and walnut, stating the weight which will be required to tear asunder slips taken from the four sides of the tree, and on each side in a regular progression, from the center to the circumference. The numbers of this table, corresponding to the two timbers, may therefore be considered as the average of more than fifty trials made on each, and he says that all the others were made by the same care, and therefore there is no reason for not confiding in the results.

PRACTICAL OBSERVATIONS.

The following observations on Woods, will be of great use to the practical carpenter in making a proper choice of timber, according to the purposes he may want to employ it for.

1st. The wood immediately surrounding the pith or heart, is the weakest, and its inferiority is so much more remarkable as the tree is older. Muschenbroëk's detail of experiments is decidedly in the affirmative. M. Buffon, on the other hand, says that his experience has taught him that the heart of a sound tree is the strongest, but he gives no instances; it is certain, from other experiments, on large oaks and firs, that the heart is much weaker than the exterior parts.

2d. The wood next to the bark, commonly called white or blea, is also weaker than the rest, and the wood gradually increases in strength as we recede from the centre to the blea.

3d. The wood is stronger in the middle of the trunk, than at the springing of the branches, or at the root, and the wood of the branches is weaker than that of the trunk.

4th. The wood on the north side of all trees, which grow in the European climates, is

the weakest, and that of the south side is the strongest; and the difference is most remarkable in hedge-row trees, and such as grow singly.

The heart of a tree is never in its center, but always nearer to the north side, and the annual coats of wood are thinner on that side. In conformity to this it is a general opinion of carpenters, that timber is stronger whose annual plates are thicker. The trachea, or air vessels, are weaker than the simple ligneous fibres. These air vessels are the same in diameter and number of rows, in trees of the same species, and they make the visible separation between the annual plates. Therefore when these are thicker, they contain a greater proportion of the simple ligneous fibres.

5th. All woods are more tenacious while green, and lose very considerably by drying after the tree is felled. I shall here conclude these observations with the following useful problem.

To cut the strongest Beam possible, out of a round Tree, whose Section is a given Circle.

FIG. 4. Pl. 79. Let $AEBF$, be the section, draw the diameter AB , and divide it into three equal parts at c , and e , and from either of these points, as e , draw eE , perpendicular to AB , cutting the circumference at E , and draw AE and EB ; and through the points A and B , draw AF and BF , respectively parallel to EB and EA , cutting each other at F , and $AEBF$ will be a section of the strongest beam that is possible to be cut out of the tree; $AEBF$, for the square of the depth AE or FB , multiplied into the breadth EB or FA , is then the greatest that can be produced.

From this it is plain, that the strongest beam which can be cut out of a round tree, does not contain the most timber, for the greatest rectangle that can be inscribed in a circle is a square, and therefore the square $FGHI$, is greater than the rectangle $AFBE$, and yet is not the strongest. See also the explanation and observations on fig. 4, from which much useful information may be deduced, when timber of peculiar strength is wanted.

The *Compression of timber* is another consideration worth our attention.

In considering strains of this kind, it is absolutely impossible to conceive how a piece of timber that is perfectly straight, can be bent, crippled or broken, by any force whatever acting at the extremes. But suppose the smallest force whatever, acting in the middle, in a direction perpendicular to the length; this force will be sufficient to give it a small degree of curvature, and if a strong force be supposed to act at the ends at the same time, each pressing the timber in the direction of its length, these forces will greatly contribute towards breaking it.

It is easy therefore to conceive, that if a piece of timber be the least bent whatever, or if the fibres of that timber are not quite straight, that there is a certain force which, if acting at the ends, will break it. Thus suppose the column ACB , fig. 9, resting on the ground at B , and loaded at the top with a weight A , acting in a vertical direction AB , and if the fibres, or the piece ACB , is the smallest degree crooked, the degree of curvature

ture by the pressure at the two ends, will be increased until the fibres are bent to their utmost extent, and the smallest addition at the ends will break it.

The first author who has considered the compression of columns with attention, is the celebrated *Euler*, who published in the Berlin Memoirs for 1757, his Theory on the Strength of Columns. The general proposition established by this Theory, is that the strength of prismatic columns is in the direct quadruplicate ratio of their diameters, and the inverse ratio of their lengths: he prosecuted this subject in the Petersburg Commentaries for 1778, confirming his former theory. *Muschenbroëk* has compared the theory with experiment, but the comparison has been very unsatisfactory; the difference from the theory being so enormous as to afford no argument for its justness, neither do they contradict it; for they are so very anomalous as to afford no conclusion or general rule whatever.

CONCLUSION.

THE strength of materials arises immediately or ultimately from the cohesion of the parts of bodies. It is necessary to have some notion of that intermedium by the intervention of which an external force applied to one part of a lever, joist or pillar, occasions a strain in a distant part. This can be nothing but the cohesion between the parts, which we call strength: it seems hardly necessary to say a tree or timber, the subject of the present discussion, is formed of numerous longitudinal fibres, which by annual growth are formed into rings, or concentric circles, and composing the trunk or stem of a tree, which by their united force of cohesion, resist separation, which may be called *absolute strength*, being exerted in the simplest form, and not modified by any relation to other circumstances. The place or part where this fracture takes place, may be called the section of fracture.

There is a certain determinate curvature for every beam which cannot be exceeded, without breaking it; for there is a certain separation of two adjoining particles, that puts an end to their cohesion. A fibre therefore can be extended only a certain determinate proportion of its length. The ultimate extension of the outer fibres must bear a certain proportion to its length; and this proportion is the same with that of the thickness (which is generally called the depth) to the radius or curvature, which is therefore determinate.

The section of fracture may be thus explained: that part is called the fulcrum which is the exterior part of the concave side in the section of fracture; thus the fulcrum of *fig. 6* and *7*, is at *I*, but in *fig. 8* it is at *C*, and is the fulcrum to the lever *CB*.

When a piece of timber is breaking, that place of the timber which is in the same plan with the fractured part, and which seems to be entirely without motion is called the axis of fracture;

fracture; to explain this more fully, suppose *AB*, *fig. 6* and *7*, to be a piece of timber (viz. a joist, &c.) suspended by ropes going over pulleys at *C* and *D*; suppose a weight *G* to be laid on the middle, just sufficient to break it when counteracted by two weights *E* and *F*, suspended over the pulleys *C* and *D*, *fig. 6*, or as in *fig. 7*, supported by two props or walls; now as the quality of the timber is more or less flexible, the curvature of the beam *AHB*, will be more or less, and just before it begins to break the fibres on the convex, or under side, *AHB*, will be much extended while those on the concave or upper side, *KIL*, will be much compressed; it is evident, therefore, there must be some line between the upper and under sides in the fracture which is at rest, or which suffers neither expansion nor compression. This line in the section of fracture is called the axis of fracture, and will be always nearest to the concave side, and more or less distant from it as the wood is harder or softer; and perhaps in general cases it will be about one-third of the total depth of the timber from the concave side. This may be considered as the reasons for what is said respecting mortices and tenons, when describing the best positions for them; for as the principal energy of the material is employed in resisting the expansion of the fibres, and occupies two-thirds of the depth or nearly so; so whatever portion of strength the other third part contributes by resisting compression, there will be no loss of strength, but rather gain, if a part is cut away, as for mortices, if the space be well filled with a hard body (See Du Hamel's Experiments), provided it be not too hard, for then it will eat into the abutting parts. For it is evident, the tendency to resist compression, will be rather increased than decreased by the foreign body thus drove in; but in cutting away the under or convex side, no foreign matter whatever can increase, nay can make up, the strength which is lost by destroying the continuity of the fibres. Further, a mechanical reason may be thus deduced:—because the same quantity of fibres if cut away from the convex side, would, if solid, make a greater resistance on the convex side, than the same number of fibres on the concave side, because the fibres on the concave side are nearer to the axis of fracture than those on the convex side; but the greater distance the fibres are from this axis, the more will they resist fracture. We wish this fact to be well considered and understood by all practical men, as it will tend to prevent many errors which may otherwise arise to the great detriment of their work. It also fully establishes the rule, that whatever is to be cut away for the purpose of mortices, &c. must be done on the concave side, which, in instances like *fig. 6* and *7*, is the upper side; but if the action of the weight or pressure is changed, as in *fig. 8*, then the mortice must be cut on the under side, which is become the concave side.

These figures 6 and 7, are shewn in positions the most common in which beams are liable to be broken by strains; the pressure on each wall is equal to half the weight of the beam and of the weight *G*; this will clearly appear by considering *fig. 6*, for the weight *G*, and the weight of the beam, must be considered as one total, for they both unite to break the beam in the same direction, and therefore the sum of the weights *E* and *F*, which act in an opposite direction, viz. on the under side, must be equal to the weight of the beam and the weight *G*, together; that is, each weight must be half, wherefore the walls which perform the same office as the weights, carrying each a half of the weight of the beam with its load *G*.

A little more to illustrate this subject: *fig. 8*, is a beam supported by a prop *CD* in the middle, and weights *E* and *F* are hung to the ends sufficient to break it; here the axis of the fracture will be nearest the under edge of the beam, as that is the convex and compressed side. In this case it is evident that the pressure upon the prop at *C* is equal to the weight of the beam, together with the two weights *E* and *F*; and this pressure would be the same at *C*, if one half of the beam *AB*, that is *AG*, was built in a wall, and the axis of the fracture would not be varied, and the strain on the upper or convex side *G*, by the weight *F*, would be nearly the same, if the end at *A* in the wall, had liberty to turn downwards; but if it is built close above and below, it will support a weight greater than *F*.

Addition to the Description of PLATE LXXIX.

By some accident the following description belonging to *FIG. 4*, *PLATE 79*, was omitted, viz. That the straps at the ends of the tie-beam are not of the usual construction, but run in the direction of the beam round the ends of the rafters, and are fixed by bolting the other end of the strap to the tie-beam.

F I N I S.



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